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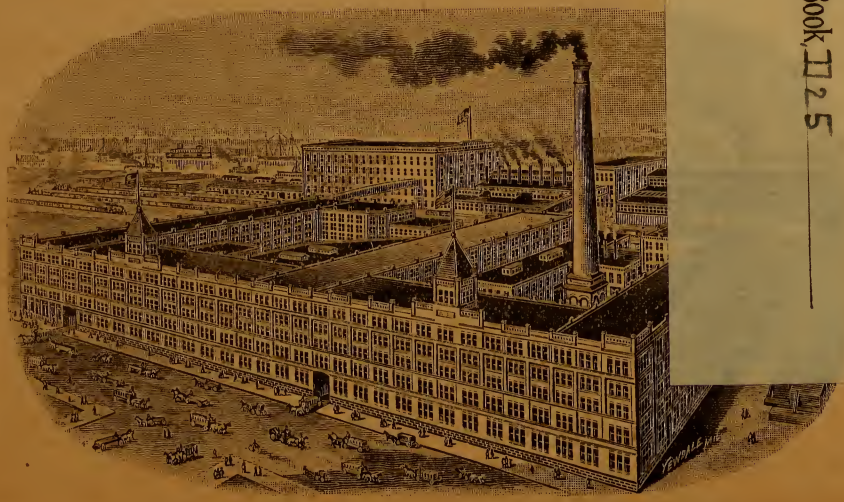

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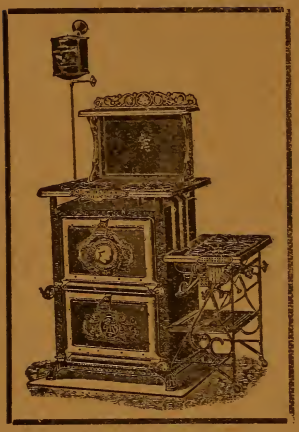

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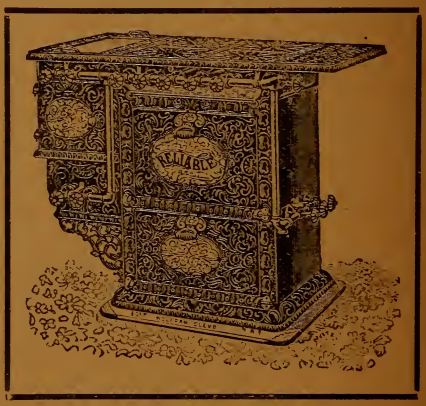

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THE

WORKSHOP MANUAL

AND

Compendium of Useful Information

COMPILED BY

JOHN J. DAVIES

FOR

Sheet Metal Workers and Mechanics of all kinds,
Business Men, Manufacturers, Etc.

CHICAGO,
THE AMERICAN ARTISAN PRESS,
1896.

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PREFACE.

THERE is nothing new under the sun. Every month sees thousands of books ushered into the world that merely flail again the thoroughly threshed straws of the ages. In a work of the character of this one, originality is not, of course, looked for. Judicious or injudicious selection from the masses of Gradgrindian fact left us from the labors of generations of calculators, statisticians and compilers, is the only factor in determining its success or failure. A furniture worker, a doctor of veterinary science, and a sheet metal worker all need books of ready reference to aid them in a thousand odd ways in their daily toil, but the data each would post himself upon are radically different. It is for the last class and those in kindred lines, such as hardware, heating, or roofing, that this book is specially intended. The greatest care has been

taken to make this Manual comprehensive without being voluminous, and compact without being at all incomplete. Its contents are in the main of a technical nature, and the few departures made into the field of general information will, it is trusted, increase the helpfulness of this little book to those for whom it was written.

THE AUTHOR.

Chicago, Nov. 18, 1895.

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CHAPTER I.

WORKSHOP RECEIPTS.

For Cementing, Soldering, Varnishing, Painting Metals, Preventing Rust, Etc.

In the following pages will be found a condensed and carefully compiled list of receipts. The lists of solders, varnishes and cements are unusually complete, and it has been the aim of the author of this work to furnish those receipts that are more commonly used, rather than the *rara avis* which one sheet metal worker or storekeeper in 500 may have an occasion to employ once in a lifetime.

Babbitt Metal—Melt four pounds copper, add by degrees twelve pounds best Banca tin, eight pounds regulus of antimony and twelve pounds more of tin. After four or five pounds tin have been added, reduce the heat to a dull red, then add the remainder of the metal as above. This composition is termed "hardening." For lining, take one pound of this hardening and melt with it two pounds Banca tin, which produces the lining ready for use. The proportions of Babbitt metal ready for use are, therefore, four pounds copper, eight pounds regulus of antimony, and ninety-six pounds tin.

Blue Print—FORMULA FOR—(1) 1 oz. of red potash, 1 oz. of citrate iron of ammonium, 1 pint of water.

*(2) 1 oz. of red potash, 1¼ oz. of citrate iron of ammonium, 1½ pint of water.

*No. 2 gives the clearer print.

Brass—Formula for Cleaning—(1) Venetian red finely powdered, 3 troy ozs.; oil of turpentine, 12 fluid ozs.; oleic acid, 1 fluid oz.; ammonia water, half fluid oz; alcohol, 1 fluid oz.; oil of sassafras, 10 minims; mix, shake on using. Apply with rag and clean off, when dry, with whiting.

(2) Oxalic acid dissolved in soft water, say half an ounce to a pint, is one of the best known means for cleaning and brightening brass work.

Brass—Cut Chemically—To cut sheet brass chemically the following method meets with success: Make a strong solution of bichloride of mercury in alcohol. With a quill pen draw a line across the brass where it is to be cut. Let it dry on, and, with the same pen, draw over this line with nitric acid. The brass may then be broken across like glass cut with a diamond.

Brazing—Cold Without Fire or Lamp—Fluoric acid, 1; oxymuriatic acid, 1; mix in a lead bottle. Put a chalk mark each side where you want to braze. This mixture will keep about six months in one bottle.

Castings—Formula for Enameling—Treat the castings with dilute hydrochloric acid, which dissolves a little of the metal, and leaves a skin of homeogeneous graphite holding well to the iron. The article is then washed in a receiver with hot or cold water, or cooked in steam, so as to remove completely the iron chloride that has been formed. Finally, the piece is allowed to dry in the empty receiver, and a solution of india rubber or gutta percha, in essence of petroleum, is injected, and the solvent, afterward evaporating, leaves a hard and solid enamel on the surface of the iron work. Another plan is to keep the chloride of

iron on the metal instead of washing it off, and to plunge the piece into a bath of soda silicate and borate. Thus is formed a silico-borate of iron, very hard and brilliant, which fills the pores of the metal skin. As for the chlorine disengaged, it continues with the soda to form sodium chloride, which remains in the pickle.

Cast Iron—MENDING—Take two ounces of sal ammoniac, one ounce of sublimed sulphur and one pound cast-iron fillings; mix in a mortar and keep the powder perfectly dry. When it is to be used mix it with twenty times its weight of clean iron fillings, grind the whole in a mortar, wet with water until it becomes a paste and apply to the parts to be mended.

Cement—FOR CASTINGS—Eighty parts of sifted cast iron turnings, two parts of powdered sal-ammoniac, and one part sulphur made into a thick paste with water and mixed fresh for use, makes a good cement for stopping holes in castings.

Cement—FOR CELLULOID—A good cement for celluloid is made from one part shellac dissolved in one part of spirits of camphor, and three to four parts of 90 per cent alcohol. The cement should be applied warm, and the broken parts securely held together until the solvent has entirely evaporated.

Cement—FOR GLASS LETTERS—To fasten glass letters, figures, etc., on glass (show windows), so that even when submerged in water for several days they will not become detached, use an India rubber cement. The best for this purpose consists of one part India rubber, three parts of mastic and fifty parts chloroform. Let it stand for several days at a low temperature to dis-

solve the cement. It must be applied very rapidly, as it becomes thick very soon.

Cement—For Iron—Take ten parts of steel filings, 3 parts sal-ammoniac, and 2 parts flowers of sulphur. This mixture can be preserved any length of time in dry packages. In order to lute with it, add to one part of the mixture 12 parts of iron filings, and enough water, previously acidulated with sulphuric acid, to form a paste. This is now ready to be applied to the perfectly clean surfaces of the metal to be luted. For fine castings and small holes, the pulverized iron (*Ferrum Pulveratum* of apothecaries) can be substituted for iron filings.

Cement—For Iron—Take equal parts of sulphur and white lead, with about a sixth of borax; incorporate the three so as to form one homogeneous mass. When going to apply it, wet it with strong sulphuric acid and place a thin layer of it between the two pieces of iron, which should then be pressed together. In five days it will be perfectly dry, all traces of the cement having vanished, and the iron will have the appearance of having been welded together.

Cement—For Joints—Paris white, ground, four pounds; litharge, ground, ten pounds; yellow ochre, fine, half a pound; half ounce of hemp, cut short; mix well together with linseed to a stiff putty. This cement is good for joints on steam water pipes. It will set under water.

Cement—For Kerosene Lamps—Rosin three parts, caustic soda one part, water five parts, mixed with half its weight of plaster of paris. This cement sets firmly in about three-quarters of an hour and has great adhe-

sive power. It is not permeable to kerosene, and is a low conductor of heat.

Cement—METALS TO GLASS—Take 4 ounces thick solution of glue, 2 ounces linseed oil varnish, 1 ounce pure turpentine. Mix and boil them together in a close vessel. When the cement is applied the metal and glass to be joined should be clamped and permitted to remain so for 48 hours, so as to allow the cement to take strong hold and to harden.

Cement—RUBBER TO WOOD OR METAL—As rubber plates and rings are now almost exclusively used for making connections between steam and other pipes and apparatus, much annoyance is often experienced by the impossibility or imperfections of an air-tight connection. This is avoided entirely by employing a cement which fastens alike well to the rubber and to the metal or wood. Such cement is prepared by a solution of shellac in ammonia. This is best made by soaking pulverized shellac in ten times its weight of strong ammonia, when a shiny mass is obtained, which in three or four weeks will become liquid without the use of hot water. This softens the rubber, which becomes, after the volatilization of the ammonia, hard and impermeable to gases and fluids.

Cement—STEAM FITTINGS—Take 6 parts of finely powdered graphite, 3 parts of slacked lime, and 8 parts of sulphate lime, and mix them well with 7 parts of boiled linseed oil. The mass must be well kneaded so as to become perfectly homogeneous. This cement is impermeable by air and steam, and is therefore valua ble to steam and gas fitters.

Cement—STEAM PIPES—Take 2 parts of litharge, 1 part dry-slacked lime, and 1 part fine dry sand. Com-

bine them thoroughly, and add enough hot linseed oil varnish to form a paste-like mass. This will be found an excellent cement entirely to be depended upon, for iron steam pipes. It sets hard quickly, and must be freshly prepared every time it is required for application, which application must be made only when the cement is quite hot.

Cement—SUBMARINE—Take 2 gills litharge, 2 gills plaster of paris, 2 gills fine dry white sand, two-thirds of a gill of finely-powdered resin. Sift and keep them until required for use, when they should be made into a putty by mixing them with boiled linseed oil, to which a little dryer has been added. It should be used within 12 hours after being mixed.

The above cement is the one employed in constructing the tanks of the Zoological Gardens in London, and is perfectly free from anything that will injure animal or vegetable life. It is but little known, but is entirely reliable. It adheres firmly to glass, metal, wood, stone, etc., and hardens under water. It can be used for marine as well as fresh water aquaria, as it resists the action of salt water. Three or four hours should be given it to dry before being subjected to the water.

Cement—TRANSPARENT—To make a perfectly white, transparent and very adhesive cement, mix in a well-stoppered bottle ten drachms of chloroform with twelve and a half drachms of non-vulcanized caoutchouc, in small pieces. When the caoutchouc is dissolved, add two and a half drachms of mastic, and let the whole macerate from eight to ten days, shaking the mixture occasionally.

Cement — WOOD ROOFING — This composition is formed of the following materials, viz.:—Mineral coal

tar, pulverized coal (charcoal is esteemed the best) and fine well-slacked lime; the coal and lime to be well mixed together, proportioned at about four-fifths coal, and one-fifth lime; the tar to be heated, and, while hot, thickened with the mixture of coal and lime, until it becomes so hard that it may be easily spread upon the surface of a board, and not run when hot. The cement most be applied warm, and should be used with a trowel.

Cement—Zinc and Glass—An inexpensive cement for uniting zinc with glass may be made as follows: 1 pound of shellac dissolved in 1 pint alcohol, with one-twentieth its volume of a solution of gutta percha in bisulphide of carbon, will dry quickly. A slow-drying one may be made thus: 2 ounces of thick glue solution, 1 ounce linseed oil varnish, or ¾ ounce Venice turpentine; boil together.

Cloth—To Tin—A mixture of finely pulverized metallic zinc and albumen, of about the consistency of a thin paste, is spread with a brush upon linen or cotton cloth, and by means of hot steam coagulated. The cloth is now immersed in a bath of stannic chloride, well-washed and dried. Running the cloth through a roller press, the thin film is said to take metallic luster. Designs cut in stout paper letters, numbers, etc., when laid between cloth and roller, are impressed upon it. It can also be cut in strips, corners, etc.

Files—Hardening—Rub a little hard soap across the teeth to keep from scaling; heat to a cherry red, and dip endwise in salt water; then dip in hot fresh water to remove any salt on the teeth, dry over the fire, and wet slightly with linseed oil on a rag.

Fire Grenades—Solution for—Bicarbonate of am-

monia and sulphate of soda in strong solution is the best solution for hand grenades to extinguish fire. This compound will keep indefinitely without losing its active properties if the bottle is kept well corked.

Ink—For Rubber Stamps—For blue ink: Aniline blue, water sol. 1 B, 3 parts; Pyroligneous acid, 10 parts; Glycerine, 70 parts; Distilled Water, 10 parts; Alcohol, 10 parts; Mix them intimately by trituration in a mortar. (The blue should be well rubbed down with the water, and the glycerine gradually added. When solution is effected, the other ingredients are added.)

Other colors are produced by substituting for the blue any one of the following: Methyl violet, 3 B, 3 parts; Methyl green, yellowish, 4 parts; Nigrosin W, (blue black), 4 parts; Diamond fuchsin I, 2 parts; Vesuvin B (brown) 5 parts.

If a bright red ink is required, 3 parts of eosin BBN are used, but the pyroligneous acid must be omitted, as this would destroy the eosin. Other aniline colors, when used for stamping ink, require to be acidulated.

Lacquer—For Brass—One quart of alcohol, 98 per cent., one and one-half ounce of best orange shellac, one-quarter ounce gum sandarach, one-quarter ounce gum elemi. Mix and keep gently warm for two or three days, stirring occasionally, and strain; give it a wine color with dragon's blood. Warm the articles before applying the lacquer.

Lacquer—Colorless—For a colorless lacquer dissolve bleached shellac in pure alcohol, settle and decant. Make the laquer very thin. The usual lacquer for brass is made with ordinary shellac and alcohol made very thin, settled and decanted.

Lead Coating—For Iron or Steel Plates—The

material to be treated is subjected to a series of five baths. The first is in a pickel, through which a weak current of electricity is passed. This bath removes the scales from the surface of the metal, and the electricity is said to greatly expedite matters. The second bath is in lime water, which neutralizes the acid. Then comes the bath in clear water. The fourth bath is in a neutral solution of zinc and stannic chlorides. The drying process, which follows, leaves on the surface of the plates a deposit of the mixed metallic chlorides, which protects the plate from oxidation. The next process consists in passing the plates through a bath of molten lead, and when taken from here the metal is found to be coated with an adherent layer of lead, which, though thin, is uniformly spread. It is said this process has no decreasing effect on the ductility or strength of the iron, and that a plate may be bent, closed and opened again without cracking the coating.

Lubricant—Put pure olive oil into a clear glass bottle with strips of sheet lead and expose it to the sun for two or three weeks, then pour off the clear oil and the result is a lubricant which will neither gum nor corrode. It is used for watches and fine machinery of all kinds.

Metal Polish—PASTE—A "paste" metal polish for cleaning and polishing brass is thus made: Oxalic acid 1 part, iron peroxide 15 parts, powdered rotten stone 20 parts, palm oil 60 parts, petrolatum 4 parts. See that solids are thoroughly pulverized and sifted, then add and thoroughly incorporate oil and petrolatum.

Mucilage—Here is the formula for preparing mucilage such as is sold in stationery stores: Dextrine 2 parts, acetic acid 1 part, water 5 parts, alcohol 1 part.

Nickel Plating—The following process of nickel plat-

ing trailing wheel parts and similar articles, is said to have given excellent results. The bath is composed of 1,000 g. of pure nickel sulphate, 750 g. of neutral tartaric acid-ammonia, 5 g. of gallic acid (tannin), and 20 l. of water. The neutral tartaric acid-ammonia is obtained by saturation of a solution of tartaric acid with ammonia. The nickel salt must be neutral. For this purpose the whole is dissolved in 3 to 4 of water, and allowed to boil a quarter of an hour. Then as much water is added as will produce altogether 20 l. of fluid, which is filtered. The precipitate obtained is very white, soft and uniform, and bears no traces of roughness on the surface. On the crude or polished castings very heavy deposits can be obtained, and at a price which scarcely exceeds that of copper plating. Galvanoplastic impressions may also be obtained in this bath. The current need only be weak.

Nickel Polish—Take one ounce of oxalic acid, one pound tripoli and one-half gallon of water, (soft water preferable). Shake once or twice a day and let stand until dissolved. Apply with woolen cloth and polish with woolen cloth or chamois.

Oxidizing—SILVER OR COPPER—To make a liquid that will oxidize silver a glossy black by dipping small silver articles in the liquid: Use a solution of sulphide of potassium; polish metal before, and rub with a soft rag or chamois after immersion. To make a liquid that will oxidize copper or oroide by dipping to imitate bronze: Use the same bath, but have it quite dilute. If for outside work simply oil with olive oil, and let the weather do the rest.

Paper—TRANSPARENT—To make paper transparent for copying, drawing, etc. Place a blank sheet of paper

over the drawing and rub it lightly with pure benzine. The tracing can then be readily made, and the benzine, upon evaporation, leaves the paper as opaque as before.

Paint—For Galvanized Iron—The best paint where a dark color is not objectionable is common asphalt dissolved in turpentine or benzine. It is extremely tenacious, dries soon and becomes very hard and insoluble by the action of sunlight. It is flexible and very durable.

Paint—For Sheet Iron—Good varnish, one-half gallon; boiled linseed oil one-half gallon; add red lead sufficient to bring to the consistency of common paint. Apply with brush. Applicable to any kind of iron work exposed to the weather.

Paint—For Tin or Iron Roofs—Ten pounds Venetian red, one gallon common asphaltum; mix thoroughly and when required take whatever quantity desired and thin with benzine to consistency of cream.

Paint—Lead Colored—Take any sufficient quantity of common litharge, and place it over a fire in a shovel; afterwards when sufficiently warm scatter over it a little flour of brimstone, which will instantly convert it into a blackish color, and which, when ground in oil, makes a good dark lead color. It dries quickly, gets remarkably hard and resists the weather better than any lead color.

Rusting—Preserving Iron Work From—(1) The material required is a cow's horn (the toy trumpets sold in the shops will answer the purpose). Heat the iron and rub the edge of the horn over it. If the horn smokes a little as you rub it on you will know that the iron is hot enough. This will cause the horn to melt,

and an imperceptible coating will be left upon the iron that will afford complete protection from the damp for a year or more on out-door work. On in-door iron work it will last indefinitely.

(2) Iron or steel immersed warm in a solution of carbonate of soda (washing soda) for a few minutes will not rust.

Rusting—To Prevent Iron and Steel From—The following mixture forms an excellent brown coating for preventing iron and steel from rust: Dissolve two parts crystallized iron chloride, two antimony chloride and one tannin in four of water, and apply with sponge or rag and let dry. Then another coat of paint is applied, and again another if necessary, until the color becomes dark as desired. When dry it is washed with water, allowed to dry again, and the surface polished with boiled linseed oil. The antimony chloride must be as nearly neutral as possible.

Rust—Removing From Iron or Steel—Cover with sweet oil well rubbed on. In 48 hours use unslacked lime powdered very fine. Rub it till the rust disappears. To prevent rust, mix with fat oil varnish four-fifths of well rectified spirits of turpentine, Apply the varnish by means of a sponge. Articles varnished in this manner will retain their brilliancy, and never contract any spots of rust. It may be applied to copper philosophical instruments, etc.

Rust—Removing From Nickel Plate—To remove rust stains from nickel plate, grease the rust stains with oil, and after a few days rub thoroughly with a cloth moistened with ammonia. If any spots still remain, remove them with dilute hydro-chloric acid and polish with tripoli.

Rusting—PREVENTING SHEET IRON PIPES FROM—The sections should be coated with a coal tar and then filled with light wood shavings, and the latter set on fire. It is declared that the effect of this treatment will be to render the iron practically proof against rust for an indefinite period, rendering future painting unnecessary.

Rusting—KEEPING TOOLS FROM—Take ½ oz. camphor, dissolve in 1 lb. melted lard; take off the scum and mix in as much black lead (graphite) as will give it an iron color. Clean the tools and smear with this mixture. After twenty-four hours rub clean with a soft linen cloth. The tools will keep clean for months under ordinary circumstances.

Silver—WASH FOR CLEANING—Take one pound of common hard soap, three tablespoonfuls of spirit of turpentine, and half a tumblerful of water. Allow the soap to dissolve; then boil ten minutes, and before it cools add six tablespoonfuls of hartshorn. Make a suds of this preparation and wash the article to be cleaned with it.

Soap—FOR METAL WORK—The basis is cocoanut oil. Its ingredients are stated to be cocoanut oil 2.05 kilos, chalk 180 grms., and alum, cream of tartar, and white lead, of each 87.5 grms. The oil is melted in an iron vessel containing a little water and the other ingredients are added in the order named, while constantly stirring the mixture. The mixture is then decanted into molds wherein it solidifies. In use it is made into a paste with water and applied either by cotton waste or a rag.

Solder—ALUMINUM—Copper 56 parts, zinc 46 parts and tin 2 parts, applied with borax. Some tests made at Neuhausen showed that with these solders plates of

aluminum soldered together, edge to edge, required a tractive effort of from 16½ to 18 tons per square inch to pull them asunder, if the edges overlapped, 22¼ tons per square inch were required. Pieces of cast aluminum bronze, if placed in sand molds, can be joined together autogenously by running in some of the molten metal. If this operation is properly carried out the joint is indistinguishable from the rest of the casting. Thin cylinders of aluminum are made in this way by bending the sheets round end to end, and soldering with molten aluminum.

Solder—ALUMINUM—For sheet aluminum an iron-tin solder may be used with a flux composed of resin, neutral chloride of zinc, and grease. The metal should not be cleaned or scraped unless it is absolutely necessary to do so, in which case alcohol, or essence of turpentine should be used for the purpose. For 5 per cent. aluminum bronze tin solder may be employed, but this is not possible with the 10 per cent. alloy, in which case a preliminary copper plating is to be recommended. If it is difficult to dip the ends to be plated directly into the solution pieces of blotting paper soaked in a solution of $CuSO_4$ may be laid on them and a current passed. The flux mentioned above may be used.

Solder—ALUMINUM—Cadmium, zinc, and tin mixed in substantially the following proportions: Cadmium, 50 per cent.; zinc, 20 per cent.; tin, the remainder. The zinc is first melted in any suitable vessel, when the cadmium is added, and then the tin in pieces. The mass must be well heated, stirred, and then poured.

Solder—BISMUTH—Tin, 1; lead, 3; bismuth, 3.

Solder—BLACK—Copper, 2; zinc, 3; tin, 2. *Another*—Sheet brass, 20; tin, 6; zinc, 1.

Solder—Brass—(1) Copper, 3; zinc, 1; with borax.

(2) Copper, 61¼, zinc, 38¾.

Solder—Brass—that will stand hammering. Brass, 78.26; zinc, 17.41; silver, 4.33; add a little chloride of potassium to your borax for a flux.

Solder—Brass, White—Copper, 57.41; tin, 14.60; zinc, 27.99.

Solder—Brass, Yellow—Copper, 32; zinc, 30; tin, 1.

(2) Copper, 45; zinc, 55.

Solder—For Brittania Ware—Hardening—(To be mixed separately from the other ingredients)—Copper, 2; tin, 1.

Solder—For Brittania Ware—Soft—Tin, 8; lead, 5.

Solder—For Raised Brittania Ware—Whited—Tin, 100; hardening, 8; antimony, 8.

Soldering—Cold Without Fire or Lamp—Bismuth, ¼ oz.; quicklime, ¼ oz.; block tin filings, 1 oz.; muriatic acid, 1 oz.; all mixed together.

Solder—Copper—(1) Tin, 2; lead, 1. When the copper is thick heat it by a naked fire; if thin, use a tinned copper tool. Use muriate or chloride of zinc as a flux. The same solder will do for iron, cast iron or steel; if the pieces are thick heat by a naked fire, or immerse in the solder.

(2) Copper, 10; zinc, 9.

(3) Brass, 6; zinc, 1; tin, 1. Melt together well, and pour out to cool.

(4) When it is desired to solder bright copper and to have the solder the same color as the copper surface, it may be done in this way: Moisten the solder with a saturated solution of vitriol of copper and then touching the solder with an iron or steel wire, a thin

skin of copper is precipitated, which can be thickened by repeating the process several times.

To make the solder brass-colored, if it is desired to gild the soldered spot, it is first coated with copper in the manner indicated above, and then with gum or isinglass and powdered with bronze powder. The surface thus obtained may, after drying, be brightly polished.

Solder—GLAZIERS—Tin, 3; lead, 1.

Solder—HARD—Copper, 2; zinc, 1. Melt together.

Solder—IRON—The best solder for iron is good tough brass with a little borax. In soldering, the surfaces to be joined are made perfectly clean and smooth and then covered with sal ammoniac, rosin, or other flux; the solder is then applied, being melted and smoothed over by a tinned soldering iron.

Solder—IRON TO STEEL OR EITHER TO BRASS—Tin, 3; copper, 39½; zinc, 7½. When applied in a molten state it will firmly unite metals first named to each other.

Solder—PEWTER—Lead, 1 part; bismuth, 1 to 2 parts.

Solder—PEWTERER'S SOFT—Bismuth, 2; lead, 4; tin, 3.

Solder—PLATINUM—Gold with borax.

Solder—PLUMBERS—(1) Bismuth, 1; lead, 5; tin, 3; is a first-class composition.

(2) Lead, 2 parts; tin, 1 part.

Solder—SPELTER—Equal parts copper and zinc.

Soldering—FLUX FOR STEEL—Chloride of zinc (muriate of zinc, killed spirit, made by putting ordinary zinc in spirits of salts—hydro-chloric or muriatic acid—

till action ceases) for use with soldering bit. The above, or sal-ammoniac (chloride of ammonia), if the job can be heated and rubbed.

Solder—STEEL JOINTS—Silver, 19; copper, 1; brass, 2. Melt all together.

Solder—TINNERS—Lead, 1 part; tin, 1 part.

Solder—ZINC—Tin, 1 part; lead, 1 to 2 parts.

Stove Polish—Grind any non-combustible black pigment with a sufficient quantity of silicate of potash, or 'liquid glass,' to make it of a proper consistency for application. When the polish becomes dry, it will be found to be smooth and shining, wholly without odor, and very durable, while it will not soil the whitest cambric if applied to it. The materials are easily obtained, inexpensive, readily mixed and applied, and the article will amply repay one for the small amount of trouble and outlay it involves.

Tin-Bronzing—Tin and tin alloys, after careful cleansing from oxide and grease, are handsomely and permanently bronzed if brushed over with a solution of one part of sulphate copper (bluestone), and one part of sulphate of iron (copperas) in twenty parts of water. When this has dried, the surface should be brushed with a solution of one part of acetate of copper (verdigris) in acetic acid. After several applications and dryings of the last named, the surface is polished with a soft brush and bloodstone powder. The raised portions are then rubbed off with soft leather moistened with wax and turpentine, followed by a rubbing with dry leather.

Tin Foil—CRYSTALLINE SURFACE FOR—Take of chloride tin, 2 parts; hot water, 4 parts; uriatic Acid, 2 parts; nitric acid, 1 part, Mix. The tin foil is dipped in this mixture and left until the crystals ap-

pear. Small crystals are obtained when the solution is applied cold—large when used hot. The most beautiful specimens of this kind are produced with varnishes colored with the aniline dyes.

Tinning—Copper, Brass and Iron in the Cold Without Apparatus—Carefully clean the article to be tinned, seeing that it is free of oxide and grease-spots. Chemical or mechanical means may be employed in cleaning. Then take the best zinc powder, which may be readily obtained by melting zinc and pouring it slowly into water in a thin stream, when it can be easily pulverized after solidification. It should be about as fine as writing sand. Next have ready a solution of protochloride of tin containing about 5 to 10 per cent. of tin salt, to which as much pulverized cream of tartar must be added as will go on the point of a knife. The object to be tinned may now be moistened with the tin solution, after which it should be rubbed hard with the zinc powder. The tinning appears at once. The tin salt is decomposed by the zinc, metallic tin being deposited. When the article tinned is polished brass or copper, it appears as beautiful as if silvered, and retains its lustre for a long time. The process is an excellent one for preserving iron, steel, copper, and brass instruments and apparatus from rust.

Varnish—Black, for Gasolene Stoves—Asphaltum, two pounds; boiled linseed oil, one pint; oil of turpentine, two quarts. Fuse the asphaltum in an iron pot; boil the linseed oil and add while hot. Stir well and remove from the fire. When partly cooled add the oil of turpentine.

Varnish—For Brass—A coat of varnish made in the proportion of two ounces of shellac to nine ounces of alcohol, will prevent brass from tarnishing.

Varnish—For Bright Iron Work—Dissolve three pounds of resin in ten pints boiled linseed oil, and add two pounds of turpentine.

Varnish—Brilliant Black—For cooking and gasolene stoves: asphaltum, two pounds; boiled linseed oil, one pint; oil of turpentine, two quarts. Fuse the asphaltum in an iron pot, boil the linseed oil and add while hot; stir well and remove from the fire. When partially cooled add the oil of turpentine. Some makers add driers.

Varnish—Coating Metals—One part of copal, one part of oil of rosemary, in two or three parts of absolute alcohol, supplies a clear varnish as limpid as water. It should be applied hot. When dry it will prove hard and durable.

Varnish—Colored for Tin—Thirty grammes of acetate of copper are ground into fine powder in a mortar, then spread out in a thin layer on porcelain plate and left for a few days in a moderately warm place. By this time the water of crystallization, and most of the acetic acid will have escaped. The light brown powder that is left is triturated with some oil of turpentine in mortar, and then stirred into one hundred grammes of fine fatty copal varnish warmed to 75 degrees C. If the acetate of copper is exceedingly fine, the greater part of it will dissolve by a quarter hour's stirring. The varnish is then put in a glass bottle and placed for a few days in a warm place, shaking frequently.

The small quantity of acetate of copper that settles can be used in making the next lot. This varnish is dark green, but when applied to tin it requires four or five coats to get a fine lustre, but two coats are sufficient if heated in a drying closet, or on a uniformly

heated plate to produce a great variety of shades of gold, a greenish gold, a yellow or dark yellow gold, then an orange

Varnish—Durable Black for Iron—Mix with a small quantity of oil turpentine, drop by drop, oil of vitriol, until it forms a syrupy precipitate which no longer increases in bulk. The mass is then poured over with water, stirred well, the water removed, and repeated as often as it shows trace of acid on litmus paper. The remaining precipitate is then strained dry, and when required for use a portion of it is placed on the iron (stove, etc.) and the stove heated and the powder burned. If too thick a layer, it must be thinned and spread out with more turpentine, so as to give a uniform coating to the metallic surface. The residue left after burning is then rubbed in with a rag dipped in flax-seed oil, until the proper polish has been acquired.

Varnish—Gilded Articles—Gum-lac ingrain, 125 parts; gamboge, 125; dragon's blood, 125; annotto, 125; saffron, 32. Each resin must be dissolved in 1,000 parts by measure of alcohol of 90 per cent; a separate tincture must be made of dragon's blood, another of annotto in 1,000 parts of such alcohol, and a proper proportion of each added to the varnish according to the shade of golden color wanted.

Varnish—Gold—Turpentine varnish, 2 gallons; turpentine, 1 gallon; asphaltum, 1 gill; umber, 8 ounces; yellow aniline, 4 ounces; gamboge, 1 pound. Boil and mix for 10 hours.

Varnish—For Iron and Steel—The following varnish will maintain its transparency and the metallic brilliancy of the articles will not be obscured: Dissolve ten parts of clear grains of mastic, five parts of cam-

phor, five parts of sandarach and five parts of elemi in a sufficient quantity of alcohol, and apply without heat.

Varnish—MORDANT—One of the simplest of these varnishes which are chiefly used when a coating of some other substance, such as gold leaf, is to be entirely or in part laid over them, is that procured by dissolving a little honey in thick glue. It has the effect of greatly heightening the color of the gold.

Varnish—SMOKE STACK—One of the best varnishes for smoke-stacks or steam pipes, is good asphaltum dissolved in oil of turpentine.

Zinc—TO BLACKEN—Zinc may be given a fine black color by first cleaning its surface with sand and sulphuric acid, and afterward immersing it for a moment in a solution composed of 4 parts each of sulphate of nickel and ammonia, and 40 parts of water, acidulated with 1 part of sulphuric acid, washing and drying it. The black coating adheres firmly, and becomes a bronze color under the burnisher.

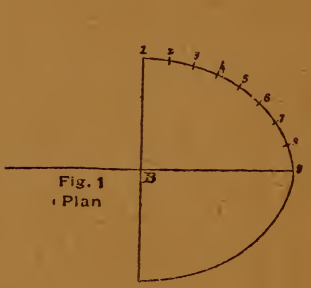
Zinc—TO COLOR—A mode of coloring articles of cast zinc in black is to take a solution of 1·8 oz. chloride of antimony in a pint of alcohol; add to it 1·2 oz. hydrochloric acid, and apply with a brush to the zinc which is to be blackened. Now dry the object, and, should the color not be sufficiently uniform, apply a second coat, and again dry as rapidly as possible by the aid of heat. The color is permanent and may be improved by rubbing with a little linseed oil, which preserves the object and gives it a beautiful polish.

CHAPTER II.

PATTERN CUTTING.

In the following pages will be found several patterns for articles in common use, as well as those for rare and graceful designs. In selecting this list frequent reference has been made to the Tinshop Department of THE AMERICAN ARTISAN and those patterns have been selected from its pages which have been most frequently requested by its readers in the past.

CONE WITH OVAL BASE AND ROUND TOP.



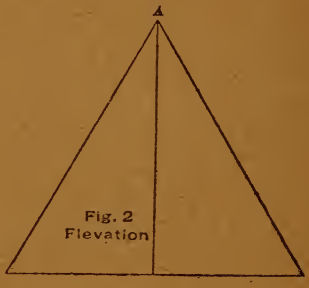


Fig. 1 is the plan, or ellipse; this we divide into equal spaces, not necessarily the entire circumference, as one-quarter is sufficient. These we number from 1 upward.

Fig. 2 is the elevation, which may be as high as circumstances require, but the higher it is the less of the arc of blank will be taken up, and the lower the elevation the more will be required. Fig. 3 is a triangle that

is required. From A′ to B′ is equal to A—B Fig. 2, or elevation of cone. Line B′, Fig. 3, to C is extended indefinitely. We now set dividers at B, Fig. 1 and carry distances the number on circumference is located to line B′ C, Fig. 3; and number correspondingly. Then the distance from A′, Fig. 3, to each of these

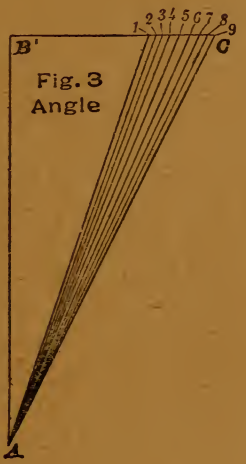


Fig. 3
Angle

numbers on line B′ C, Fig. 3, equals the distance from apex of cone to base after being formed up.

Fig. 4, or blank, we find by setting dividers at A′ and 9, Fig. 3, and with A″ as a radius strike arc d e; on this arc we space on as many spaces as we have in Fig. 1. If we have only one-quarter of Fig. 1 spaced off, we space off the remaining three-fourths of blank, and number accordingly (see Fig. 4); then we carry each line numbered from 1 to 9 in Fig. 3, to corresponding numbers in Fig. 4, using A′, Fig. 3, and A″, Fig. 4, as radii. Then by tracing through each of these lines at points of cutting, we have the pattern in its entirety. Should the cone be a large one, of necessity we should

be obliged to divide our blank into two or four pieces; if the latter, and we have already spaced our plan only

Fig. 4
Blank

one-fourth, then the same number of spaces need only be observed in blank.

TO DESCRIBE AN ELLIPSE.

Let a b, be the given major axis; bisect a b, at e; through e, draw c d, at right angles to a b, equal to the semi-major axis; place one point of dividers at e, the

other at c, and transfer on line e b, which is f; then divide the space between e f in three equal parts, and add one of the parts which is g, the centre of end radius, by placing the dividers at g a, and transfer it to line c d. We have the side radius with h as center, and g as center of end; we mark line h k, and treat the others in the same manner; this enables us to find the exact section of end and side circle by placing foot of compasses on

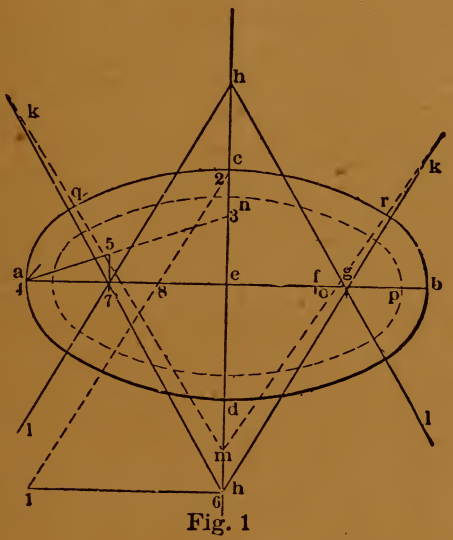


Fig. 1

h and c; describe side circle and with the foot at g, describe end circle. The dotted lines represent the bottom for a pan. In describing the body, Fig. 2, let a b be the given center-line; at right angles to a b, mark a c, equal to one-half the diameter of side circle, which is from h, to d; Fig. 1, the bottom line e d, Fig. 2, is equal to m n, Fig. 1. From the point c d, mark radius line c d b, with foot of compasses at b. We describe circle h a f, equal in length to q r, Fig. 1, and having thus

found side section we mark f g b, Fig. 2, with f g b, as center line, and at right angles to it mark f i and g j, equal to g p, and g b, Fig. 1, and from the points found, mark radius line k s m, with m as center mark circle

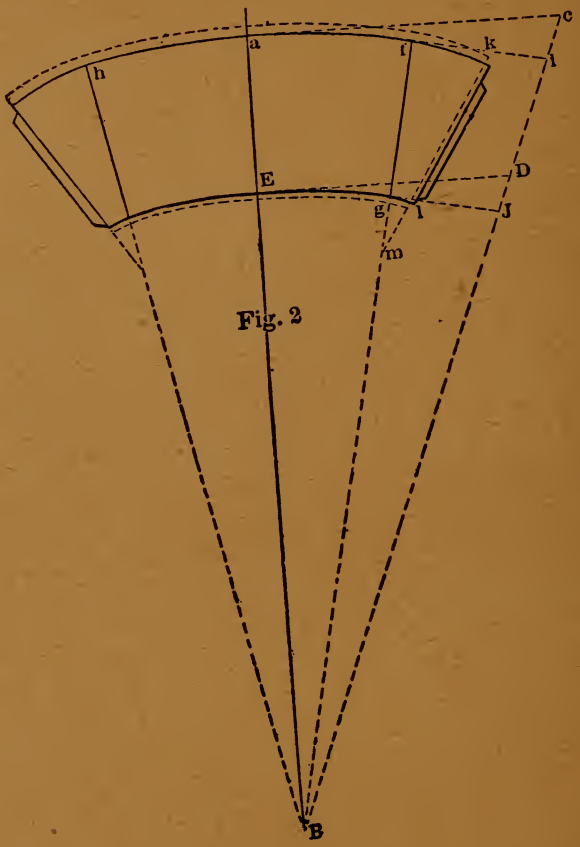


Fig. 2

equal in length to section of circle r b, Fig. 1; this gives one half of body, all edges to be allowed. In Figure 3, the cover, it is necessary to find the pitch, which is from e, to 8, and e, to 3. Set compasses at 5, and 4, Fig. 1, in Fig. 3, with 5 as center, describe circle 4, to 4,

equal to end circle of Fig. 1, and through 5, mark 4 5 1; set compasses from 1, to 2, Fig. 1, in Fig. 3, set compasses one foot at 4, and the other 1, and describe side circle equal in length to q r, Fig. 1. Again set com-

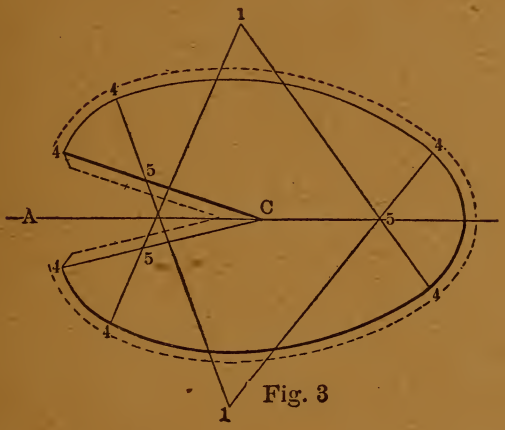


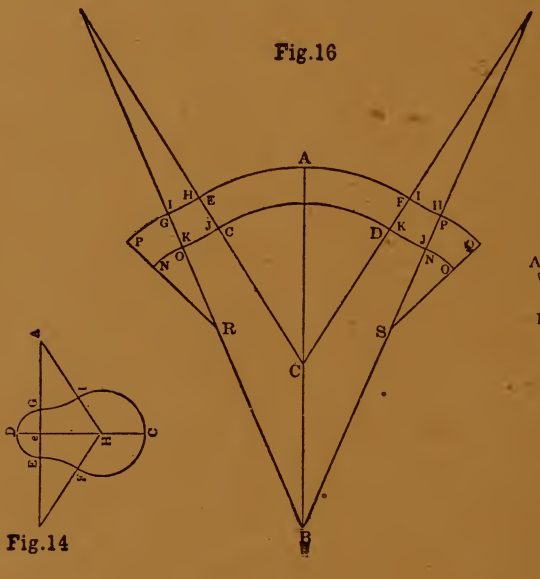
Fig. 3

passes for end circle and we describe one half of end section with one foot of compasses at 4; we divide the distance between 4, and b, which is the center, then mark lines 4, 4, to c; add locks and the pattern is found.

PATTERN FOR A TAPERING OVAL VESSEL.

Describe the bottom, the height and breadth as in Fig. 14: describe the body as in Fig. 15 and 16; describe the right angle A B C Fig. 15; make B E the altitude; draw the line D E at right angle to B C; make F E equal to G H in Fig. 14; make G B equal to F E and the taper required on a side; draw a line cutting the joints G and F and the line B C. On any right line as A B in Fig. 16, with the radius H F and H G, describe the arcs C D and E F; set off C D equal to I G F in Fig. 14; draw the lines E C and F G cutting the center at G Fig. 15, make D E equal to A B in Fig. 14; make

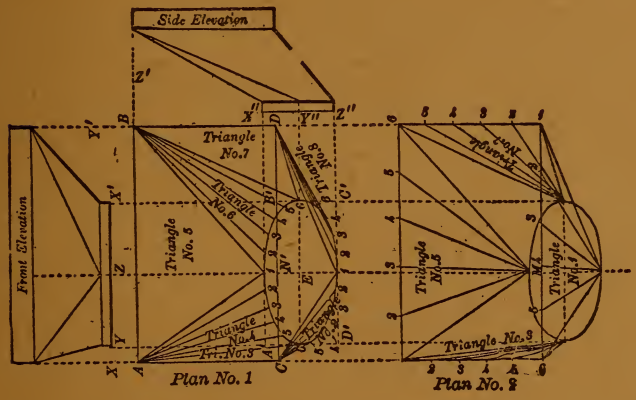
A B equal to D E and the taper required on a side; draw a line cutting the points A and D and the line B C with the radius C D and in Fig. 16, with I and H as centers, cut the lines G L and G M as at M and L; with M and L as centers describe the arcs H I and H I also the arcs J K and J K; set off H I and H I equal to I B in Fig. 14; draw the lines J H and K I cutting the centers L and M Fig. 15; make I E equal to C D in Fig. 14;



make J B equal to I E and the taper required on a side; draw a line cutting the points J and I and the line B C with the radius K I, and in Fig. 16, O and N as centers, cut the lines L B and M B as at B and S with R and S as centers; describe the arcs N O and N O also the arcs P Q and P Q; set off N O and N O equal to B D in Fig. 14; draw the lines Q O and P N, cutting the centers at S and R.

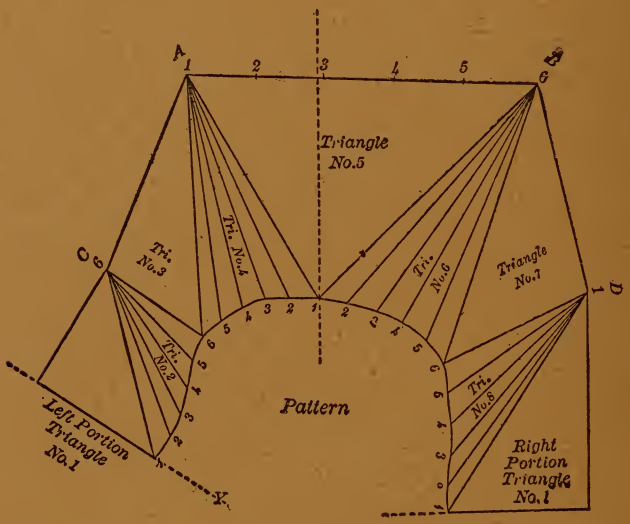
The taper must be equal on all sides. Edges to be allowed. The pattern can be cut in any number of sections.

PATTERN FOR HOPPER BY TRIANGULATION.



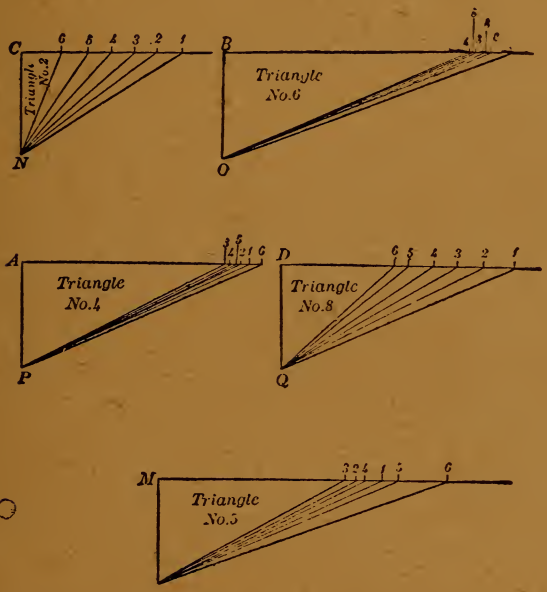
The first step in developing the form is to draw a plan as No. 1, a, b, c, d, which represents the top of the hopper. The ellipse E represents the outlet. In order to determine their relative positions it is necessary to draw the front and side elevations; having done this we drop lines x, y, z, x′ y′ z′ x″ y″ z″ at points of intersections. In a′ b′ c′ d′ we have the position of our ellipse; lines z and y″ cut and divide the ellipse into quarters; these we divide into any desired number of spaces and number as shown by Figs. 1, 2, 3, 4, 5, 6. We are now ready to construct our triangles on plan, and by looking over our work and considering our elevations and form of same, we find that points a, b, c, d are the only proper points at which to concentrate our lines. We accordingly drop lines from these points to figures on oval. as shown on plan No. 1. For convenience in developing pattern we number our triangles as

shown, 1, 2, 3, 4, 5, 6, 7, 8; these numbers also show the relative position the triangles bear to one another (the form of hopper we see calls for 8 triangles and every one is of a different form; these 8 are divided into 4 upper and 4 lower triangles, or 4 with their base down and 4 up. The base of the 4 upper correspond with the sides of the article; the hypothenuse corresponds with those of the adjoining lower triangle; and since the upper triangles are perfectly flat, and their bases form a



rectangle, we only have use for 4 triangles to work from. To show to those who are studying pattern drafting that this is the case, and to avoid confusion I draft plans No. 2 and triangle No. 5, which if they take dividers and carry lines 1, 2, 3, 4, 5, 6 to triangle No. 5 in pattern, they will find that the numbers correspond. I might add that if the top of the hopper were round or oval then we would be obliged to make use of this second set of triangles). We are now ready to form our

triangles. We take the depth of the article for the length of the perpendicular line; draw a line at right angle to this indefinitely. These triangles we number 2, 4, 6, 3 respectively, or a, b, c, d, which show us where they belong and their respective positions. We then set dividers at a in plan and extend to Fig. 1, as indicated by line running from a to 1. Carry this to triangle numbered or lettered accordingly, and all the dis-



tances to figures on oval we carry to triangles, as shown; having done this we are ready to describe our pattern. For this purpose we must determine our starting point, and there are none better than line y in our plan and elevation. We will also place our seam on this line; we draw line y and with our dividers on c extended to n′; this gives us the base of the left portion of triangle No. 1; this we carry to and at right angles to line y in pat-

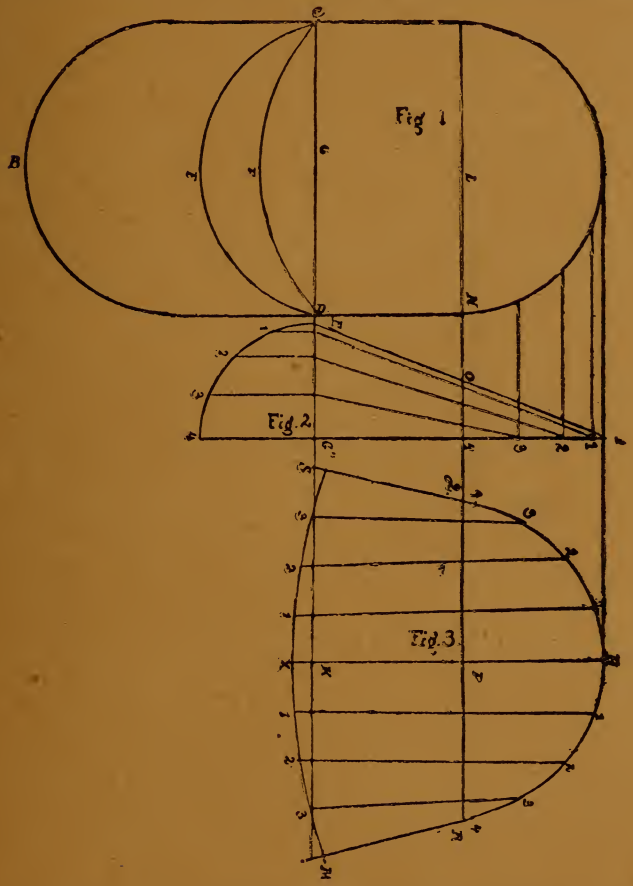
tern; now we set dividers at n in triangle No. 2 and extend to Fig. 1; carry this to pattern set at c6 and at point of intersection on line y is the depth of pattern at this point. We now carry all the remaining lines in triangle No. 2 to pattern and space to correspond with spaces in oval. We are now ready for triangle No. 3. Line 6 in triangle No. 2 is the length of one side; from c to a in plan the length of base and line 6 in triangle No. 4 the other side, or from a′ back to 6. We proceed from this point on with each of the triangles, in the same manner, and finish up right portion of triangle No. 1 in same manner as the left portion and the pattern is the result.

PATTERN FOR A CIRCULAR TOP BOILER COVER.

A B C D, Fig. 1, represents the boiler for which cover is required, G E the height it is to have when made. With dividers sweep circle that will touch points C E D.

At right-angles to A B (which is center line through the boiler) draw A I—Q 4—and G G′ indefinitely. At the point G′, Fig. 2, erect the line G′ I which will be parallel with the center line of boiler. With the dividers set as G to E, Fig. 1, place one leg on G′ and sweep the quarter-circle as shown on Fig. 2. Divide same into equal parts (in this case four) and erect lines from the points thus established till they touch the line G′ E′. Now divide the quarter-circle A, in Fig. 1, into four equal parts and carry lines parallel with A I until they meet the line G′ I, Fig. 2, and from there to the points previously obtained on the line G′ E, all as shown in diagram. Now take the distance O 4, Fig. 2, and transfer same to Fig. 1, as presented by G F, and sweep circle to strike points C F D as shown.

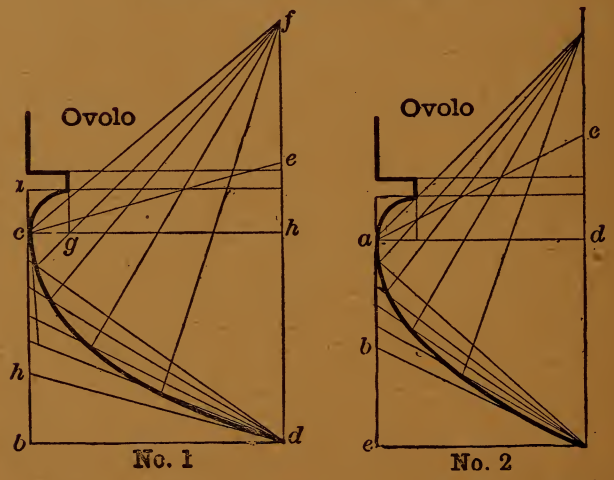
On the line A I, which has been continued indefinitely, and at any convenient point, as at H, drop the perpendicular line H K, Fig. 3. Divide the segment of circle D E, Fig. 1, into four equal parts and transfer



same to Fig. 3, spacing and marking the points on each side of K. Likewise with the chord of circle represented by D T, Fig. 1, transferring same distance on each side of P, Fig. 3, establishing the points Q and R.

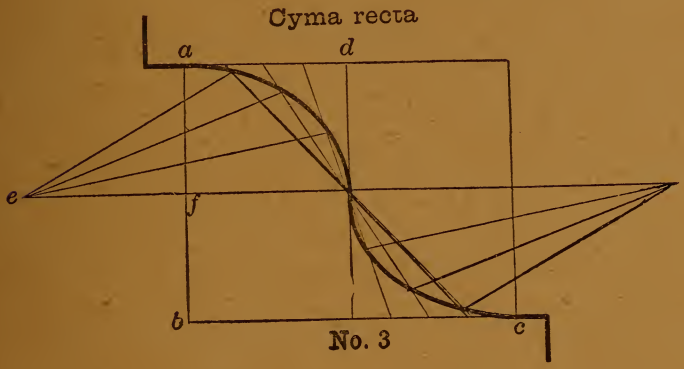
Now sweep a circle which will strike Q H R. Draw the side lines Q S and R M. Return again to Fig. 1 and set dividers same as in spacing off the one-fourth circle from A to N and on the circle just struck in Fig 3. Commencing at H, mark on each side the points 1 2 3 4; draw lines from these points on circle to dotted marks on line S K M indefinitely. Take the distance from I, to E′, Fig. 2, and with one point of dividers on H, Fig. 3, mark point X, take distance from 1 to corresponding number on line G′ E′, Fig. 2, and transfering to Fig. 3, mark point 1 on each side of X continuing till all these triangular distances, as also 4 G′, are thus taken from Fig. 2 and marked on Fig. 3. A free-hand line drawn through the intersecting points completes the required pattern. Add for seams.

GRECIAN MOULDINGS.

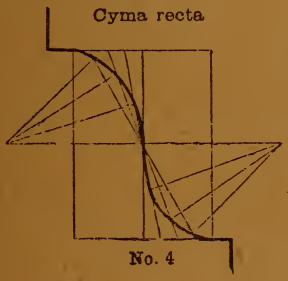


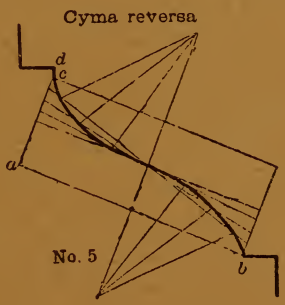
It will be seen that these are sections of mouldings produced in a perfect form and when combined with a tasteful selection of others a perfect mould is the result.

Let A B be the height and B D be the projection; the point C is one-sixth of A B, the point H is two-thirds of the distance from C to B. The distance H B is transferred to H E, a line is drawn from C to E which is divided into five equal spaces, from C to H is



divided into five equal spaces, and the space is also placed. From E to F lines are drawn as indicated. A C G represents a square. Use G as center and strike

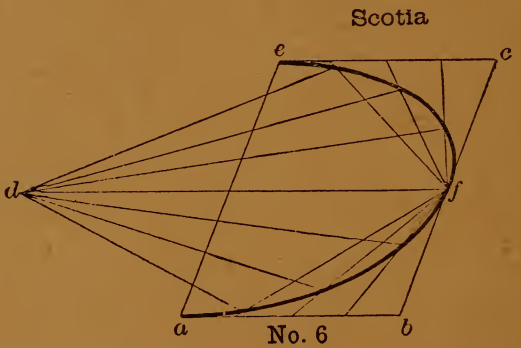




quarter circle. The profile line from C to D is traced through the intersection of the other lines.

No. 2—Ovolo is on nearly the same principle as No. 1 with the exception that A C is divided in half and the distance C D is the same as B E.

Let A B be the height and B C the projection. Divide A D into four equal parts; the line A F into four equal parts, and lines are drawn as shown by drawing. The point E is equal to A D from F. The profile line is drawn, free hand, through the points of intersection.



No. 6

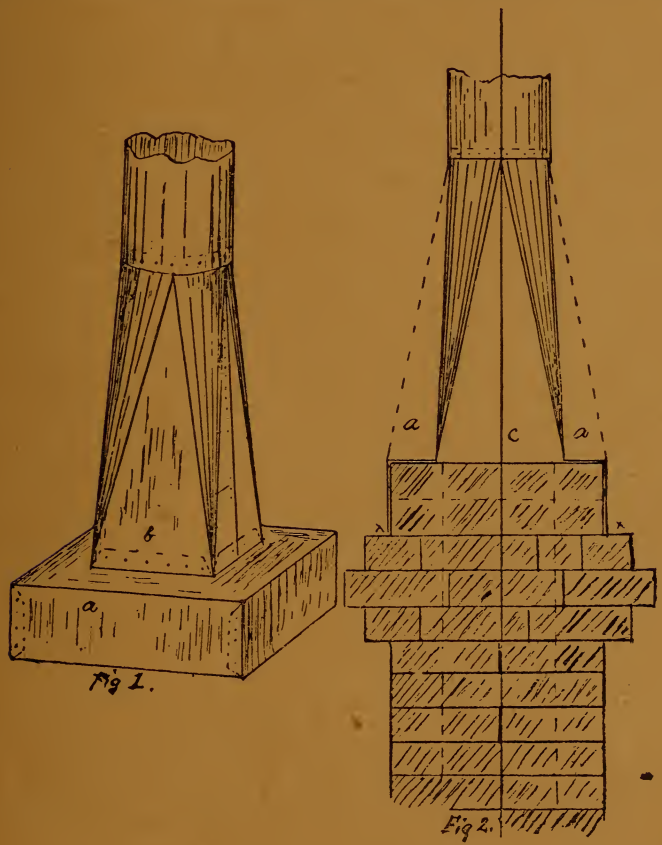
No. 4—Cyma recta is on the same principle as No. 3, it being shown on a smaller scale.

Let A B be, say, on 30 degrees. A C is very nearly the width of mould. We proceed as in the third and fourth ones. The distance C D is merely an extension of profile line.

A E and C B are on 60 degrees and the distance apart of the projection of mould. Now divide E C and A B into four equal parts each, and the line A E into eight equal parts. The point D is the same distance from the mould as the line A B. Then draw lines as shown. Draw the profile line, free hand, through the points of intersection, which finishes the mould.

PATTERNS FOR A SMOKE STACK.

Figure 1 shows a view of the base for a stack designed according to common-sense principles. The flat



bottom part of the base is made of a size that will fit the top of a chimney snugly; then to this part is attached the tapering part b, and to the top of part b the round pipe can be extended to any height desired. Fig. 2 shows the relative positions that a base made after the usual style as shown in the figure by dotted lines

has to one made after the style shown by Fig. 1. It will be seen at a glance wherein the style Fig. 1 shows many points that would recommend it over the old style. A few of these are that this design leaves no dead space on the inside of a base, as Fig. 2 shows at a a′, as is the case with the style shown by the dotted lines.

This dead space generally fills up with cold air, which in turn tends to retard the smoke ascending through

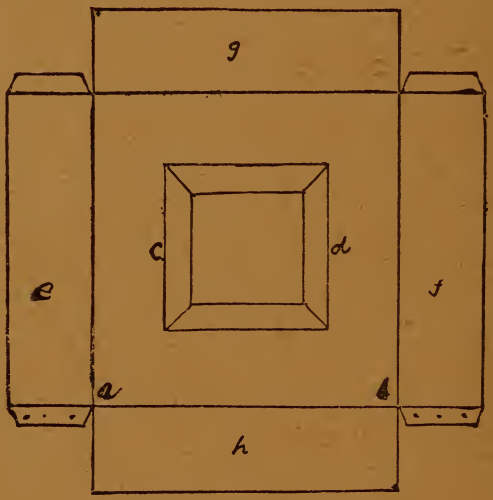


Fig 3.

the chimney by creating eddies and cooling the hot gases and smoke passing up. None of these disturbances are present in a stack like Fig. 1. Instead, an even draught is the result, by reason of the smooth surface which it presents to the ascending column of smoke. Then this style cap does not require half as much iron to construct it as one of the other kind does; consequently it can be made cheaper. The base or bottom part of the joint C, as shown by Fig. 2, should be made

a trifle wider and longer than the inside of the flue of the chimney is into which the base is to fit. This will give a solid bearing for it to rest upon in case the height and weight of the joints above this joint should demand a more substantial rest than the square base a, Fig. 1, could give to the same.

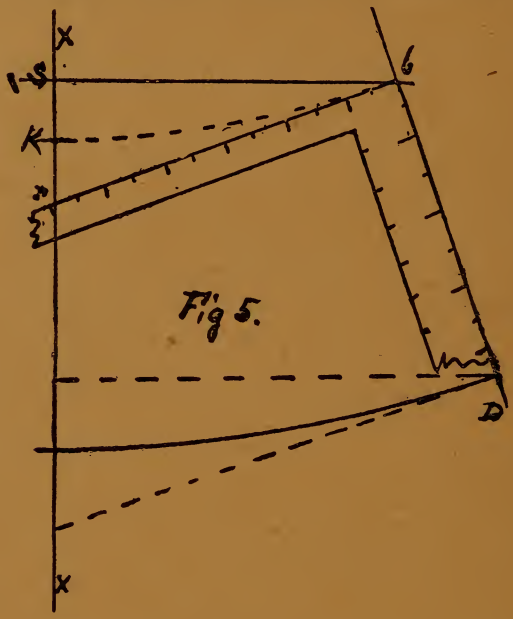
The base a of Fig. 1 can be cut of one piece, as shown by Fig. 3. From a to b is the size of the top of the chimney. The square opening. c o d, is cut somewhat

Fig 4

smaller on the four sides, as shown; these are turned up and the tapering stack is riveted to them. The sides of the base are to be cut wide enough so as to cover the bricks down to the first projection, as shown by X X of Fig. 2. The four sides are shown in the pattern, Fig. 3, by e, f g and h; e and f have laps allowed at the ends of each to rivet the sides g and h to when the base, Fig. 3, is formed up to shape.

Fig. 4 shows one-half of the tapering first-joint laid

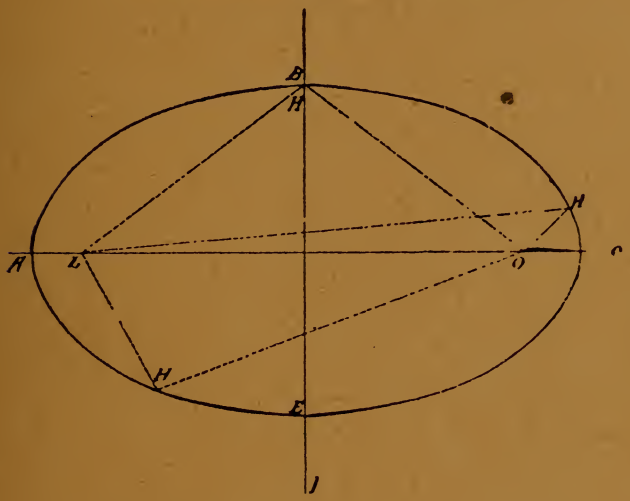
out after the usual methods used for a joint round at one end and square or rectangular at the other. The entire tapering joint can for most cases be laid out in one piece. The dotted lines shown in Fig. 4 are where the break occurs between the rounding and flat surfaces of this stack. A, b, c and D is one of the sides; if a common tinners' square is taken and laid even with the



line b d of Fig. 4, or as shown more plainly by Fig. 5, at line b d, then the blade of the square cutting the center line X X at V establishes V, the point where the sweep or curve b k cuts the center line X X. This point is just one-half the distance between points S and P of line X X. The correct points of intersection of the radius once established for one side, it becomes a very simple matter to join the other sides to it. The distance from point k to point m or n is one quarter the distance

around the circumference which the round pipe that fits the tapering joint has. The size that the round pipe is made usually for ordinary chimneys is from 6 to 9″ in diameter, 7′ being the size most used. Allow for all locks or laps.

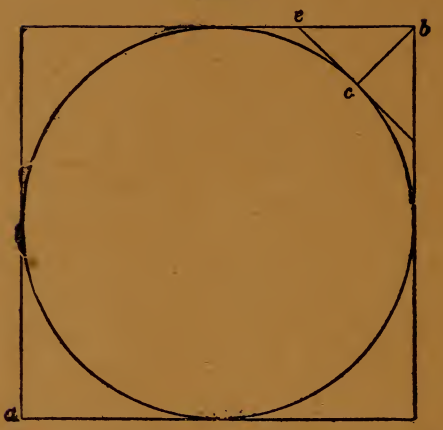
"STRING AND NAIL" OVAL.



Let A C be the long axis; set compasses on A; open until its radius exceeds one-half the length of long axis. Mark 1 2. Set compass on C and cross 1 to 2; extend a line through from 1 to 2 and you have your position for short axis, which is B E. The distance from B to L and O and E to L and O is one-half the long axis. Drive small wire nails in at L and O, over which loop a string of the exact length of long axis, as shown by the dotted lines; H is pencil and shows different positions of string as it is being moved around the oval.

THE SIDE OF AN OCTAGON.

Fig. 1

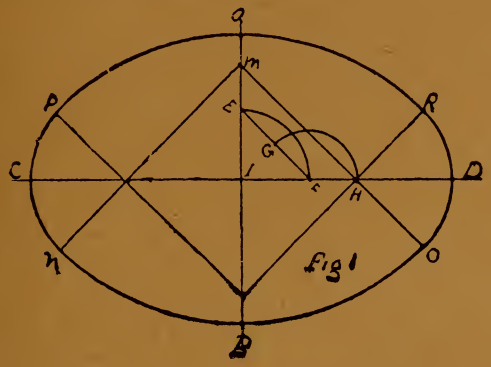


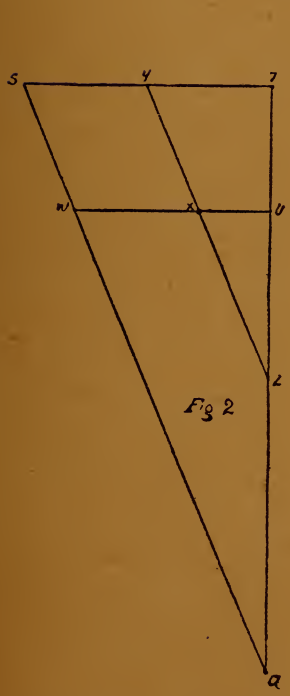
Let the outlines of Fig. 1 represent the given square. To find one side of octagon: First describe a circle touching the lines of the square as shown in diagram. Then with the square or straight edge placed at corners A B mark line C B running from corner to and touching circle at C. Next measure line C B, and make line E D from C to D and from C to E equal to C B in length; which will make the whole line E D as long again as line C B. Each corner measured as above described will form a perfect octagon.

TO DESCRIBE PATTERNS FOR FLARING VESSELS.

Lay off Fig. 1, distance from A to B equal to diameter of top, H to F, the height D E diameter of bottom. Draw lines from A B, touching D E till they intersect, which is marked C. Stretch compass from C to A; with compass thus set, draw part of circle and measure off with a piece of tin bent to suit circle the required circumference. Draw lines from these points (1, 2) of measurements to where leg of compass was

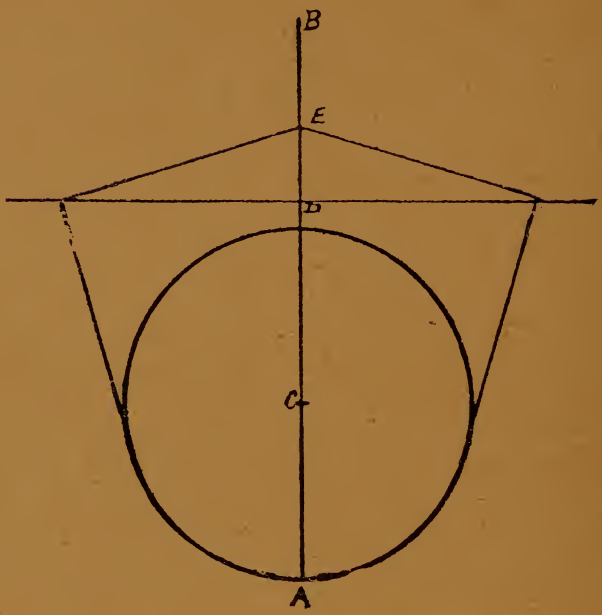
placed, which is marked 4; stretch compass from C to D and draw circle between lines 3, 5.





If desired to make in pieces divide the circumference of top by the number of pieces wanted.

PATTERN FOR A WASH BOILER COVER.



Draw circle the size of boiler body measured outside of rim. Erect line A B. Let the distance from center C to D be equal to half-length of cover, or body. Mark off from D, on line toward B, the pitch intended for cover. Then with corner of square on horizontal line D, and the blades touching circle and point E, draw lines, which gives the pattern.

PATTERN FOR A CAN BREAST OR PITCHED COVER.

The enclosed pattern is my rule for a pitched cover or can breast, of any given size or pitch, which may be a somewhat longer way of attaining it, but is much more simple than any other rule I have seen to produce this.

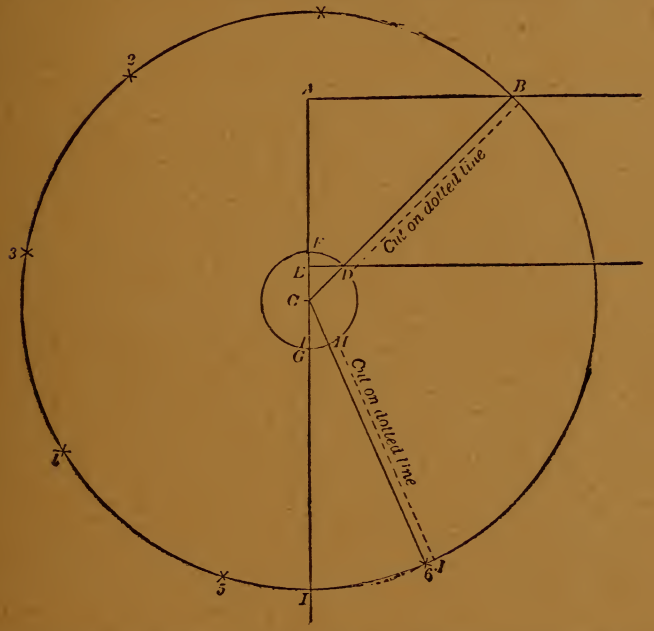
To develop this pattern proceed thus:

Draw A (B, A, C) indefinitely.

Make (A B) = to ½ diam. of can or article you wish breast or cover for.

Make (A C) = to height of pitch you wish for either breast or cover.

Draw (E D) indefinitely and at (R) angles to (a c,)



and distance from (C) to be ½ diameter of opening you wish for can breast or (C E.)

Set compasses on points (C and B) and produce the circle (B. I. J.) complete to (B) again.

Draw line connecting (B and C) intersecting the line (E D) at (D.)

Set compasses on points (C and D) and produce the article (D. F. G. H.) complete to (D) again.

Set compasses on points (A and B) and from the

point (B), step off six times this space from (A to B) (or ½ diam. of can), as Figs. (1) (2) (3) (4) (5) (6); at the point (6) (J) draw the line (J C), allow for locks as dotted line is, cut out circle (D F G A H) when for a can breast, and omit this when a pitched cover is wanted, also omit line (E D) and circle (D F G H) in pitched covers, (B. I. J. H. G. F. D.) to (B) again, is the pattern for can breast.

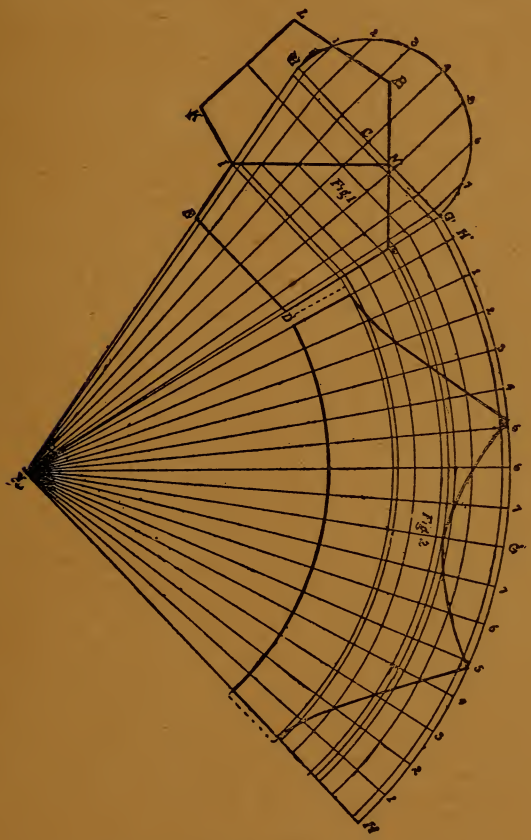
(B. I. J. H. C. D.) to (B) again, is pattern for pitched cover.

PATTERN FOR A "Y."

A, D, E, I, K, S and B, Fig. 1, represent the Y and are shown by the heavy lines. In I is the line dividing the Y into equal parts and where they are to be joined. Protract the lines A D and I E upward indefinitely; span the dividers from D to M and with one leg on D mark the point G, and also on E mark the point H and draw a line across. Now continue the lines I E and A D in the other direction until they meet at the point X, which will be the center from which to construct the pattern. With the point C as a center describe a semi-circle (to touch the points H and G), which divide into equal parts (in this case eight) and number the same as in diagram. Drop perpendicular lines from the points thus established until they strike the line G H and from thence to the center X. From the points where these lines cross I M and M A draw lines parallel with G H until they meet the line G A D.

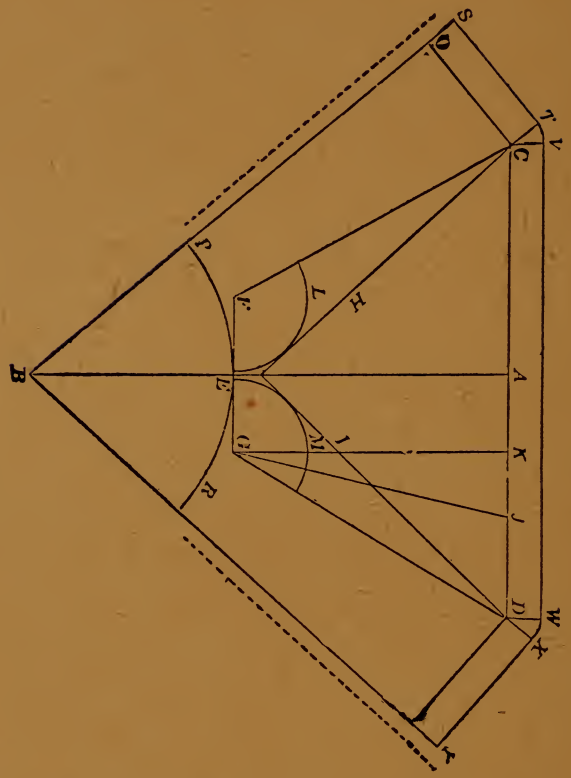
On any right line, as X, H, Fig. 2, with the compasses spanning from X to G, Fig. 1, sweep a circle indefinitely. With the compasses set as in dividing the semi-circle H and G in Fig. 1, and commencing at H, Fig. 2, mark sixteen spaces on the circular line just struck (or eight if the pattern is to be made into two pieces). In this

case it is marked to be in one piece. Draw the line X H and also from the points thus established to the center X and mark and number as in Fig. 2 Now sweep circles from all the points established on the line D G in Fig. 1, as well as the circle D N, continuing until



they intersect the line X H″. A free-hand line drawn through the intersection of these lines will be the pattern for one-half of Y. The same pattern will answer for the other half. Seams to be allowed as shown by the dotted lines.

CHIMNEY TOP PATTERN.

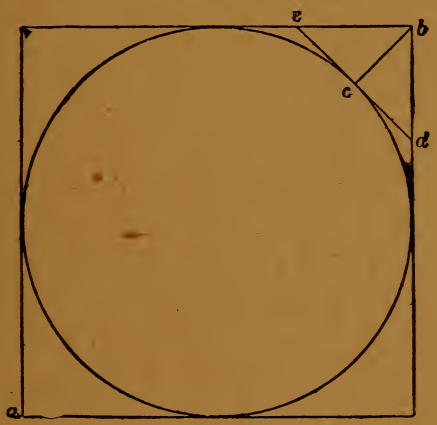


Make the horizontal line c d equal to the longest side of base. Make the line a b at right angles to a d; let a e be the height minus the flange. Draw the line f g parallel to c d; let f g be equal in length to one-fourth the circumference of top. Draw the lines g d and c e. Make the line k g parallel with a e; make a j equal to one-half the shortest side of base. Now with the radii k j describe the arcs l and m with f and g as centers. Draw the lines i d n and h c o and set off d n and o c equal to a j; make b n and b o at right angles

to d n and o c. With the radii b c describe the arc p e r using b as center. Extend s o, t c, x d and n y on lines with o b, c h, i d and n b; make s o, t c, x d and n y equal to height of flange (usually four inches). Make v c and w d at right angles to c d; make v c and w d equal to height of flange. Draw the lines s t, v w and x y. All edges on this pattern are to be allowed.

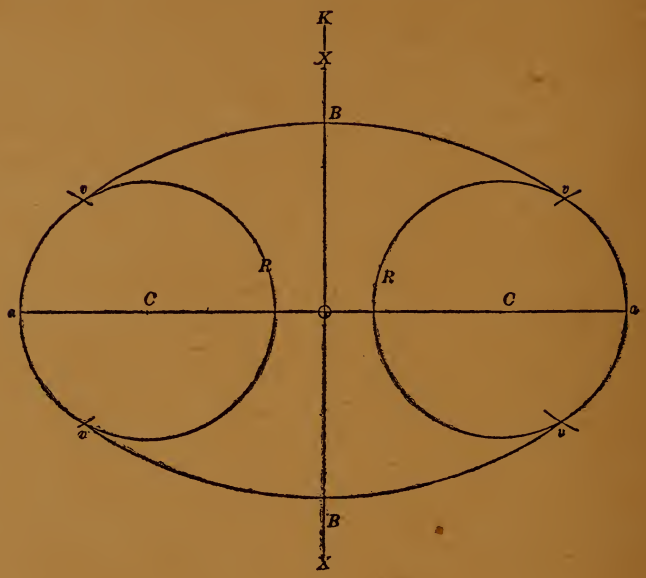
RULE FOR OBTAINING THE SIDE OF AN OCTAGON OF ANY GIVEN SQUARE.

Fig. 1



Let the outlines of Fig. 1 represent the given square. To find one side of octagon: First describe a circle touching the lines of the square as shown in diagram. Then with the square or straight edge placed at corners A B mark line C B running from corner to and touching circle at C. Next measure line C B, and make line E D from C to D and from C to E equal to C B in length, which will make the whole line E D as long again as line C B. Each corner measured as above described will form a perfect octagon.

TO DESCRIBE AN OVAL OF ANY LENGTH OR WIDTH.



Make the line A A the desired length of oval. Bisect this with the indefinite line K, and on this line make B B, the desired width. Then with one point of dividers at O, the center of oval, mark the C C equal to three-fourths of the difference between the two diameters; then with one point of compass on points C C with the radius C A describe the circle R R. Now with A A as center and the same radius cut these circles at V V V V, then the V's will be points in the curves. Take the distance from center O to circle R on line A A and set off one each side of oval on line K this distance as X X, then will from the points X X to the opposite B B be the radius for the sides of the oval.

PATTERN FOR A PRAIRIE CHIMNEY.

1st. Draw elevation as indicated in Fig. 1. A represents pitch of roof for chimney on side of roof. B represents pitch for chimney on comb of roof; strike arc as shown from C to D, or from 0 to 10; divide this arc

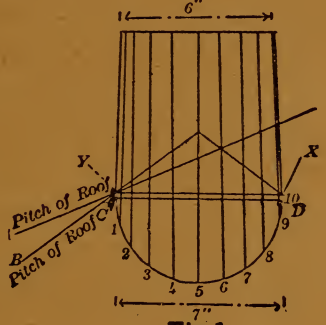


Fig.1

into equal spaces; draw lines and number as shown in plan of elevation.

For the blank, since our elevation shows by its di-

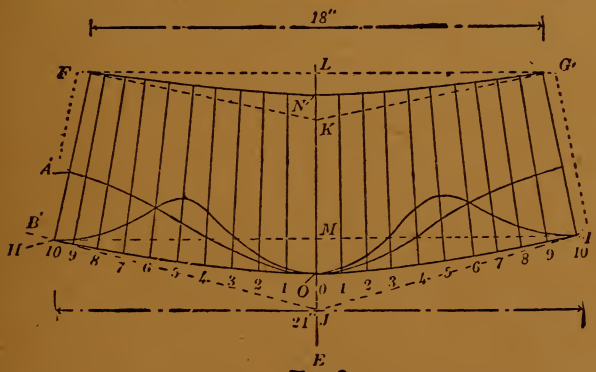


Fig.2

mensions that the arc in blank is greater than our dividers will strike, we will take our diameters 6 and 7 x 3 = 18 and 21. We strike line E, and with a square strike lines F G and H I at right angles with line E and 9 and

10½ inches on either side of line E, which equals 18″ and 21″ as shown in blank. Strike lines connecting F H and G I: place square on these latter lines and strike lines I J—H J—F K and G K; at right angles to do with G I and F H; bisect distance between K L and J M. This gives the point cut by arc, which may be made by placing a rule, either wood or steel, on F G and spring to N, and describing along the same H I and springing to O and describing complete arcs of blank. (If we take line H I and add thereto M O we find it equal H O I or 7 x 3.1416 approximately, or near enough to work by.) Now divide this blank into twice as many spaces as arc in Fig. 1 and number as shown in Fig. 2. With dividers carry distance from lines X Y to A B; pitch of roof respectively to blank and on lines that correspond in number, trace through these points and we have A′, Fig. 2, for pattern for chimney for side of roof and B′ for pattern for comb of roof. A collar for corner of chimney may be described in the same manner as the latter pattern above.

PATTERN FOR MEASURE LIP.

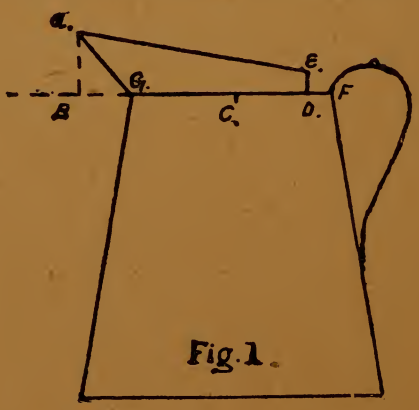


Fig. 1.

Fig. 1 represents the measure with lip. Fig. 2. Draw X Y and lines A B and C P at right angles to it, making distance A C equal to dotted line A B, Fig. 1. On line A B, Fig. 2, lay off from A to M one-half diameter of top of lip, which is distance C B, Fig. 1. On line C P lay off from C to M one-half diameter top of measure, which is distance C G, Fig. 1. Draw line through M

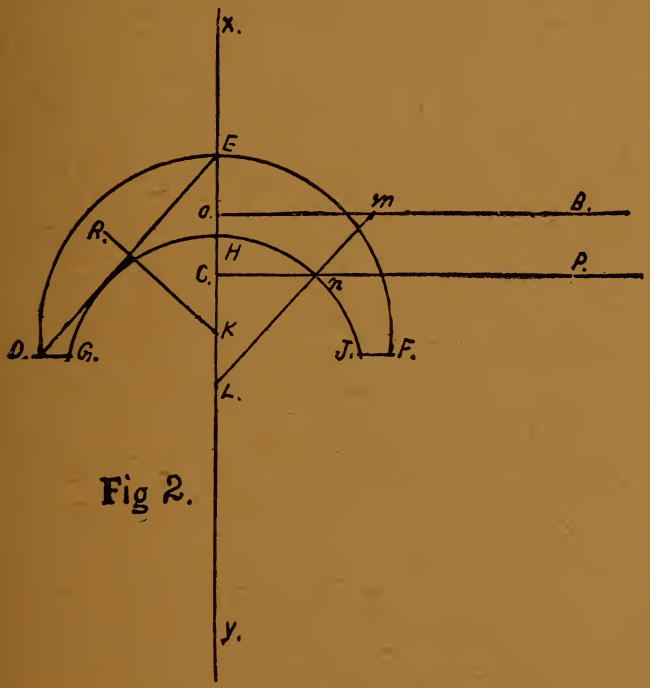
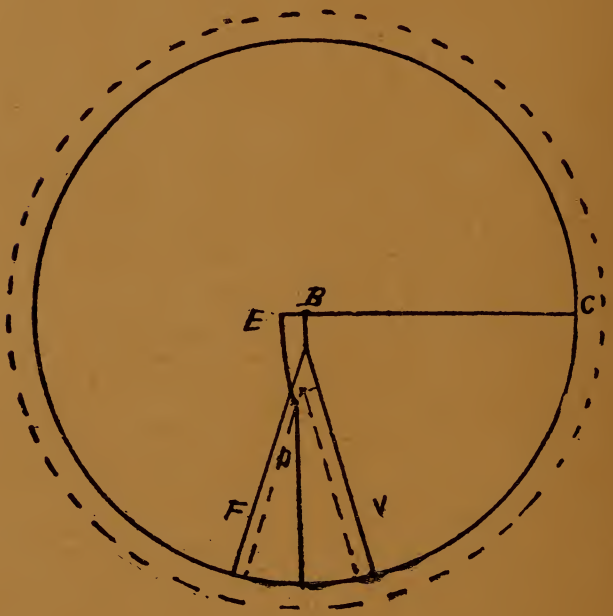


Fig 2.

and N until it intersects X Y at L. Now with L as center and radii L N strike arc G H I. Span dividers C N and span twice on arc each side of point H, which will locate points G and I. Make G D and I T equal to E D, Fig. 1. Span dividers M N and from H locate point E. Draw line D E, Fig. 2, and through its cen-

ter at right angles draw line R K until it intersects X Y at K. Now with K as center and K E radii strike arc D E T and you have it. This will give strainer pail lip by spanning three times each way from point H.

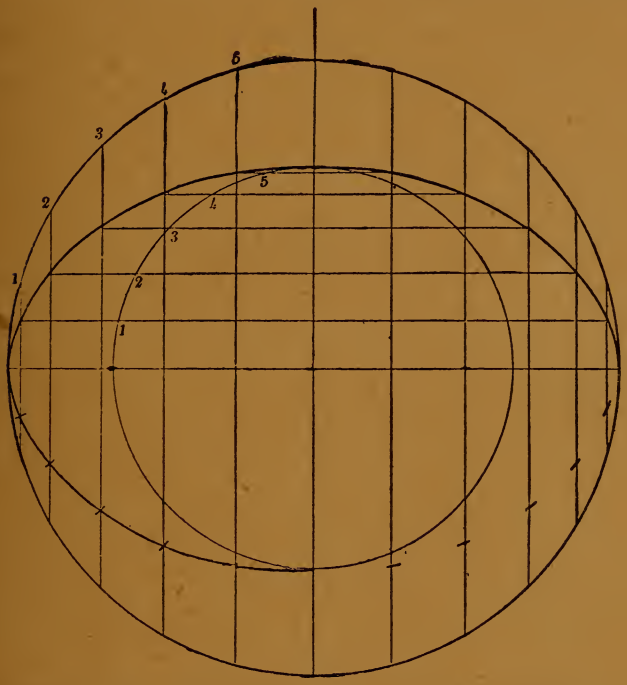
PATTERN FOR A PITCHED COVER.



Draw circle the size of rim; then place square in center and draw A B C. If for a two-inch pitch measure two inches from B down (D represents two inches), then place one leg of dividers at C and the other at D and draw line E. Then span dividers from E to B and space three times on each side of A; mark lines F L and the pattern is done. Allow for all locks and edges. Dotted lines show them.

METHOD OF DESCRIBING AN ELLIPSE.

To develop an ellipse of any given length and width desired: The outer, or larger circle is the length; the



inner, or smaller, the width. Space off each of the circles in as many spaces as may be desired.

ROMAN MOULDINGS.

Five methods for obtaining profiles of the simplest of Roman mouldings.

Divide line a, b into three equal parts; divide one-third into five equal parts, place two-fifths to the right and three-fifths to the left of line a, b on c, d; with d as center, strike arc a, e.

Fig. 2 is square; with a as center the arc b, c is made; it can be seen that by joining the two together it produces a correct O, G profile.

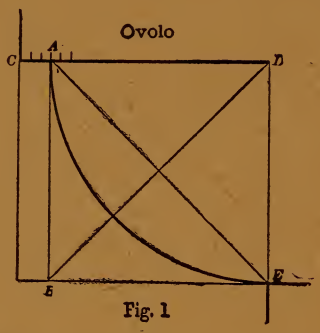


Fig. 1

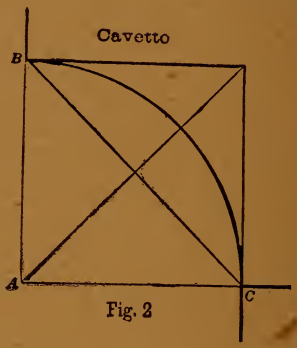


Fig. 2

Make the square a, b, c, d; mark line a, e, c with e as center; mark circle touching the four corners with a

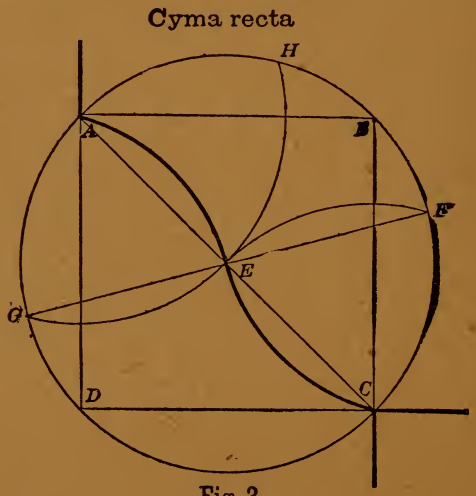


Fig. 3

as center; mark section of circle g, e, h with c as center; mark section of circle k, e, f; mark line g, e, f; with g, and f as center mark the profile line a, e, c.

Mark the line n, c the required height and the line a, b at 45 degrees passing through f the center from c,

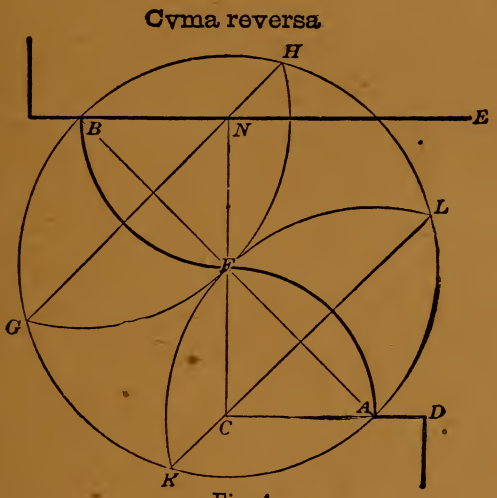


Fig. 4

d; with f as center mark the large circle; with a, and b as center mark the section of circles g, f, h and k, f, s;

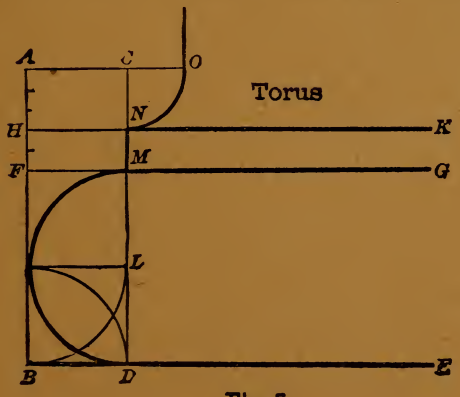


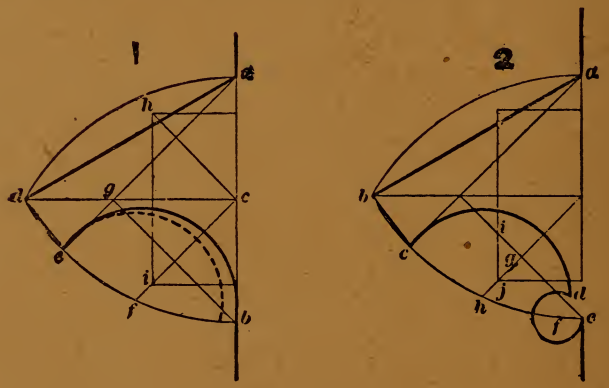
Fig. 5

mark the lines g, h and k, l; with c and n as centers mark the profile line b, f, a.

Mark the line a, b, divide it into three equal parts: divide one of the thirds into five equal parts; lay off on line b, e one of the thirds which will produce the line c, d; mark the line f, g and h, k; with l as center mark profile line d, m; with c as center mark profile line, n. o

GOTHIC PROFILES.

Fig. 1—Let A B, be the height and C D the projection. Draw the lines A E, C F, B G and C H all on a 45 degree from centers to intersect the line as indicated; the lines C H and C I are the same length as C G, which produces the two squares. With A as center strike arc D B and with B, as center the arc D A. A profile line is marked from A to D and from



D to E. With F as center strike the dotted line. Divide E B into one-half and strike profile line, E B.

It will be understood that the two squares are produced in the same manner through all of them, the height and projection are also known and it is needless to explain so clearly in the other seven of them.

Fig. 2—Draw the profile line, A B and B C; use H

as center and strike arc, C D. Divide I J into one-half; lay off from E to F that distance and strike the circle D E.

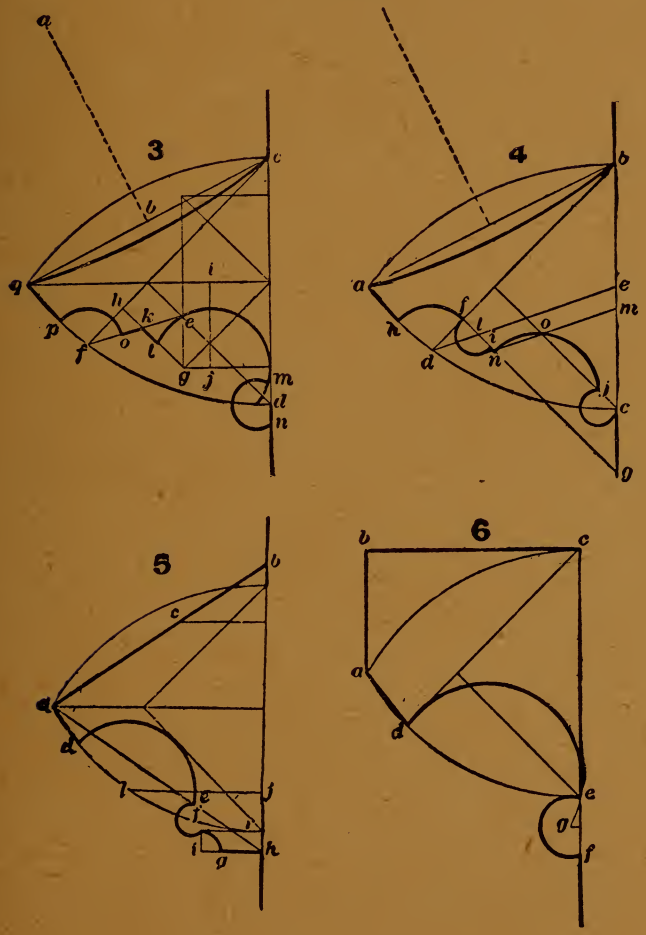


Fig. 3—Strike the section of circle which is produced by spacing up the line A B three times the height of mold C D. Mark the line I J; use J as center

and strike the circle L M, which passes through E and extends down, which produces the center for the circle M N; the distance O K is the same as K L. With F as center strike the circle C P.

Fig. 4—The profile circle A B is produced in the same way as (No. 3) the point, E is half of B C, a line drawn from it to point D. The point G is half the distance of E C. A line drawn to F at 45 degrees, with D as center strike the circle F H; with L as center strike the circle F I parallel line D E; mark the line N M touching the circle F I; now mark the circle from the point N passing through point O which, when carried down, gives the center for the circle J C.

Fig. 5—Mark the profile line A B, touching the square at C, prolong the line J to I; use I as center and strike the circle which will touch the line at O; extend. A R which will produce the center for the circle E F The horizontal line is marked from the point R to cut the circle E F. From R is measured down the radius of the circle E F; mark the line S H, and where the line R cuts the circle, drop the line which produces the center for the circle F G.

Fig. 6—The lines A B and C are at right angles. Divide the distance from D to E on blue line, into one-half which is the center for the profile [circle D E, which is extended down O, which is half the distance A D.

TEE PIPE PATTERN.

To describe a pattern of a T pipe at any angle:

Draw the line A E; erect the line A B, the angle required; also the line E D parallel to A B. Make B D equal to the diameter of the pipe; describe the semi-circle B C D; draw the line F G parallel to B D; divide

the semi-circle into any number of equal parts; from the points draw lines parallel to A B, as 1, 2, 3, etc.

Set off the line A B C equal in length to the circumference of the pipe, and the lines A F, B D and C F at

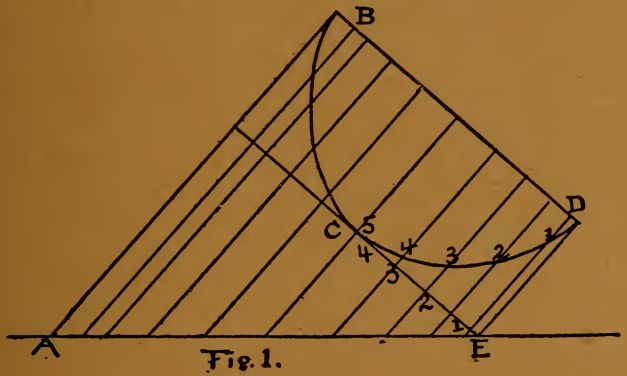


Fig. 1.

right angles to A C. Set off on each side of B D the same number of equal distances as in the semi-circle B C D, and from the points draw lines parallel to B D, as 1 1, 2 2, 3 3, etc. Make B D equal to A B, and E A and C F equal to to E D; also each of the parallel lines

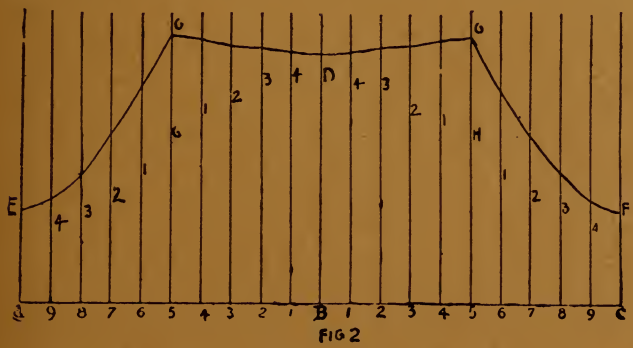
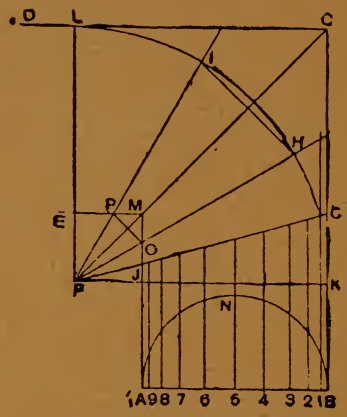


FIG 2

bearing the same figures, as 1 1, 2 2, 3 3,etc. Then a line traced through the points will form the required pattern.

Allow for edges,

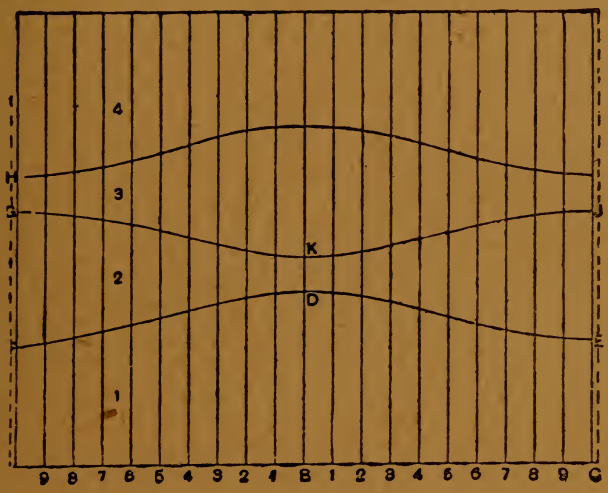
TO DESCRIBE A PATTERN FOR A FOUR-PIECE ELBOW.



Three and four piece elbows have very largely taken the place of the old right-angled elbow, on account of their better appearance, and also because they lessen obstruction to draft. The machine-made article is kept in stock for all common sizes, but the tinner is liable to be called upon at any time to make such an elbow, on account of stock being sold that is of unusual size, or other cause. Herewith are given diagrams and explanations which will enable any tinner to construct a pattern for any desired size.

Let ABED, Fig. 1, be the given elbow; draw the line FC; make FM equal in length to one-half the diameter of the elbow, with F as a center; describe the arc KL; divide the arc KL into three equal parts; draw the lines FH and FI; also the line IH; divide the section HK into two equal parts, and draw the line FG; draw the line AB at right angles to BC; describe the semi-circle ANB; divide the semi-circle into any number of equal parts; from the points draw lines parallel to BC, as 1, 2, 3, etc.

Set off the line ABC, Fig. 2, equal in length to the circumference of elbow AB; erect the lines AF, BD and CE; set off on each side of the line BD the same number of equal distances as in the semi-circle ANB; from the points draw lines parallel to BD as 1, 1, 2, 2, etc.; make BD equal to BG; make AF and CE equal to AJ; also each of the parallel lines, bearing the same number as 1, 1, 2, 2, 3, 3, etc.; then a line traced



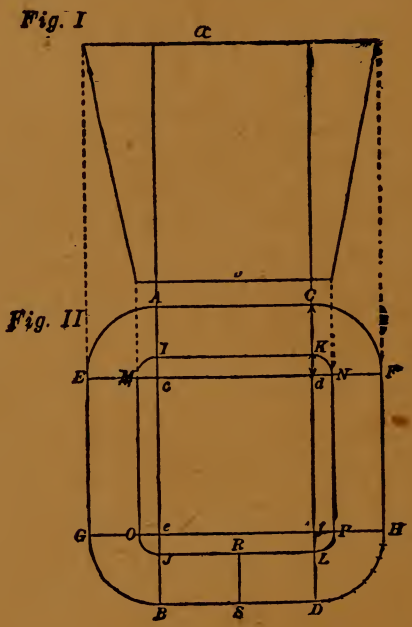
through the points will form the first section; make FG and EJ equal to HI; reverse section No. 1; place E at G and F at J; trace a line from G to J; make GH and JI equal to PO, Fig. 67, or to DK, Fig. 68, take Sec. No. 1, place F at H and E at I, and trace a line from H to I; this forms Sec. No. 3 and 4,

Edges to be allowed.

A TAPERING, ROUND-CORNERED SQUARE RESERVOIR.

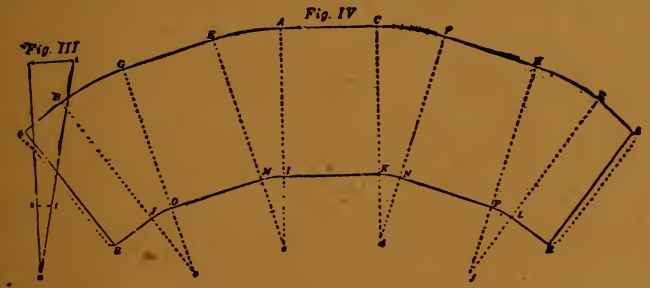
Diagrams and rules for constructing pattern for a tapering round-cornered square reservoir are herewith given:

Fig. I the upright height. Take the perpendicular Fig. I is the size, top and bottom. (A C F H D B G E is the top, and I K N P L J O M is the bottom), and height ad, Fig. I, and mark it off from h to k, Fig. III.



Take the radius for the corners dC, Fig. I, and mark it off from h to i, Fig. III, also the radius dK; mark off from K to l, drawing a line from il to cut the line hK, which gives the slanting height and the radius required for striking the corners. Draw the lines IK and AC, Fig. IV, the same length as IK, Fig. II, and the same distance apart as l to i, Fig. III, prolong the lines AI

and CK, Fig. IV, till Ac and Cd equals to i m, Fig.III With radius dC, Fig. IV, using d and c as centers, strike the curves CF and AE, and with radius dK, Fig. IV, using the same centers, strike the curves KN and IM. Take the length of the large quarter circle DH, Fig. II, and dot off the same distance from C to F, Fig. IV; make AE equal to CF, and draw lines from E and F to the centers c and d; draw EG and MO at right angles with Ec. Take the distance from A to C and make the same distance from E to G and M to O, Fig. III. Draw



Ge parallel to Ec. From G mark off point e, the same length as E to c, then using e as center, strike the curves GB and OJ, making the curve GB equal to AE; draw the line from B to center c draw BT and JR at right angles to Be, taking the distance from B to S, Fig. II, mark off the same distance from B to S, and J to R, draw SR parellel with Be, and proceed in the same manner with the other end; adding on the laps, as shown will make the pattern complete in one piece, being joined together at RS.

RULE FOR ROUND ELBOWS.

A quick rule for striking a round elbow pattern with three or four pieces.

Fig. 1 represents a three-piece elbow. It is cut the following way: First divide your circumference into

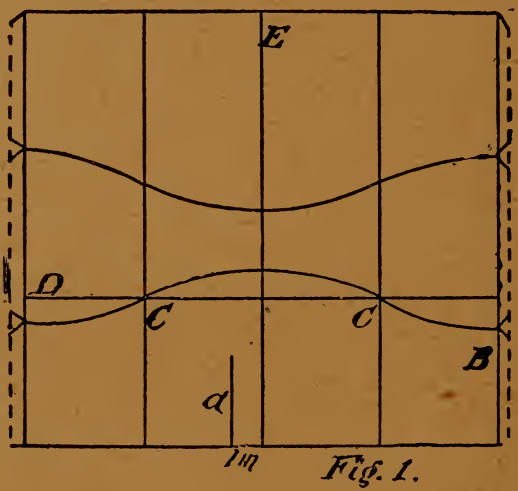


Fig. 1.

four equal parts E and C C, then draw line D. Set dividers from A to B, which is 1 in. more than one-half the circumference. For instance, we will take a 6 in.

Fig 2.

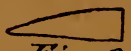


Fig 3

elbow. The circumference is 18⅞ in. (not including locks), one half of same is 9 7-16 in.; we set dividers 10 7-16 in. Then set on line and describe from C to C and from C to B, which gives the pattern; or you can make a pattern after having the dividers set as Fig. 2

and cut in half gives you Fig. 3. You can lay on line D and describe. For a four piece elbow you set dividers 1 in. more than three-fourths the circumference, and

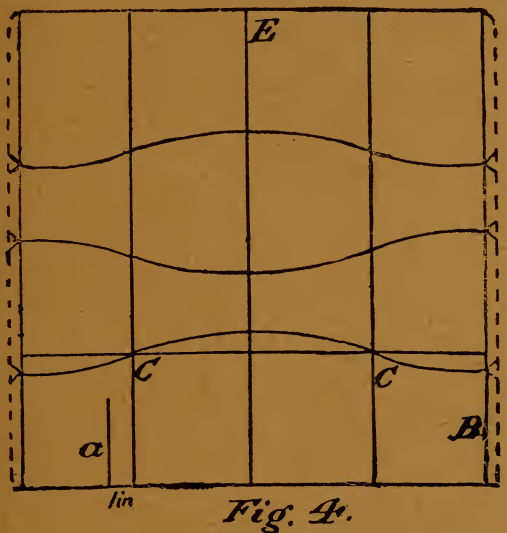


Fig. 4.

proceed the same as for three-piece as in Fig. 4. This rule is very handy for all sizes of pipe and very handy for hot air pipes, etc.

PATTERN FOR A METAL BALL.

Take a 3 in. ball; draw a circle 3 inches in diameter (Fig. 1), with T as center. Divide it into as many

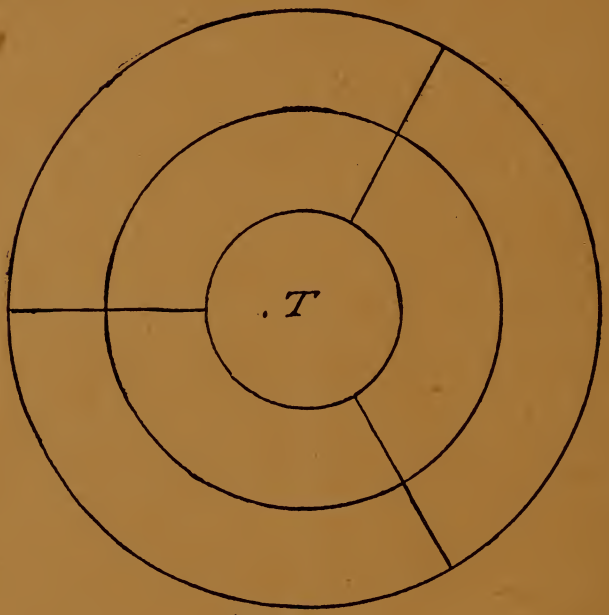


Fig. 1.

parts as desired. This is divided into thirds. Raise pieces to fit your drawing; allow edges for laps.

CHAPTER III.

MISCELLANEOUS TABLES.

NUMBER BRICKS REQUIRED TO CONSTRUCT ANY BUILDING.

(Reckoning 7 Bricks to each superficial foot.)

Superficial ft. of wall.	Number of Bricks to Thickness of					
	4 inch.	8 inch.	12 inch.	16 inch.	30 inch.	24 inch.
1.....	7	15	23	30	38	45
2.....	15	30	45	60	75	90
3.....	23	45	68	90	113	135
4.....	30	60	90	120	150	180
5.....	38	75	113	150	188	225
6.....	45	90	135	180	225	270
7.....	53	105	158	210	263	315
8.....	60	120	180	240	300	360
9.....	68	135	203	270	338	405
10.....	75	150	225	300	375	450
20.....	150	300	450	600	750	900
30.....	225	450	675	900	1,125	1,350
40.....	300	600	900	1,200	1,500	1,800
50.....	375	750	1,125	1,500	1,875	2,250
60.....	450	900	1,350	1,800	2,250	2,700
70.....	525	1,050	1,575	2,100	2,625	3,150
80.....	600	1,200	1,800	2,400	3,000	3,600
90.....	675	1,350	2,025	2,700	3,375	4,050
100.....	750	1,500	2,250	3,000	3,750	4,500
200.....	1,500	3,000	4,500	6,000	7,500	9,000
300.....	2,250	4,500	6,750	9,000	11,250	13,500
400.....	3,000	6,000	9,000	12,000	15,000	18,000
500.....	3,750	7,500	11,250	15,000	18 750	22,500
600.....	4,500	9,000	13,500	18,000	22,500	27,000
700.....	5,250	10,500	15,750	21,000	26,250	31,500
800.....	6,000	12,000	18,000	24,000	30,000	36,000
900.....	6,750	13,500	20,250	27,000	33,750	40,000
1000.....	7,500	15,000	22,500	30,000	37,500	45,000

INTEREST TABLE,

At six per cent., in dollars and cents, from one dollar to ten thousand:

	1 DAY.	1 MO.	3 MOS.	6 MOS.	12 MOS.
$	$ C.	$ C.	$ C.	$ C.	$ C.
1	00	00½	01½	03	06
2	00	01	03	06	12
3	00	01½	04½	09	18
4	00	02	06	12	24
5	00	02½	07½	15	30
6	00	03	09	18	36
7	00	03½	10½	21	42
8	00	04	12	24	48
9	00	04½	13½	27	54
10	00	05	15	30	60
20	00¼	10	30	60	1 20
30	00½	15	45	90	1 80
40	00¾	20	60	1 20	2 40
50	01	25	75	1 50	3 00
100	01½	50	1 50	3 00	6 00
200	03	1 00	3 00	6 00	12 00
300	05	1 50	4 50	9 00	18 00
400	07	2 00	6 00	12 00	24 00
500	08	2 50	7 50	15 00	30 00
1,000	17	5 00	15 00	30 00	60 00
2,000	33	10 00	30 00	60 00	120 00
3,000	50	15 00	45 00	90 00	180 00
4,000	67	20 00	60 00	120 00	240 00
5,000	83	25 00	75 00	150 00	300 00
10,000	1 67	50 00	150 00	300 00	600 00

EQUIVALENT OF BRITISH MONEY IN AMERICAN MONEY.

Shillings	Dollars. Cents. Mills.	Shillings.	Dollars. Cents. Mills.	Shillings.	Dollars. Cents. Mills.	Pounds.	Dollars. Cents.	Pounds.	Dollars. Cents.
1	$ 24 2	7	$1 69 4	13	$3 14 6	1	$4 84	15	$ 72 60
2	48 4	8	1 93 6	14	3 38 8	2	9 68	20	96 80
3	72 6	9	2 17 8	15	3 63 0	3	14 52	25	121 00
4	96 8	10	2 42 0	16	3 87 2	4	19 36	30	145 20
5	1 21 0	11	2 66 2	18	4 35 6	5	24 20	35	169 40
6	1 45 2	12	2 90 4	20	4 84 0	10	48 40	50	242 00

WEIGHT, STATURE, ETC., OF MAN.

The mean weight and stature of the human body at birth, and at every subsequent age, together with the expectancy of life from 20 to 70 years of age, is as follows:

MALES.			YEARS.		YEARS.	
Age.	Feet.	Lbs.	Age.	Expectancy.	Age.	Expectancy.
0	1.64	7.06	20	41½	46	24
2	2.60	25.01	21	40¾	47	23¼
4	3.04	31.38	22	40	48	22½
6	3.44	38.80	23	39½	49	22
9	4.00	49.45	24	38¾	50	21¼
11	4.36	59.77	25	38	51	20¼
13	4.72	75.81	26	37¼	52	19¾
15	5.07	96.40	27	36½	53.	19
17	5.36	116.56	28	35¾	54	18¼
18	5.44	127.59	29	35	55	17¾
20	5.49	132.46	30	34½	56	17
30	5.52	140.38	31	33¾	57	16¼
40	5.52	140.42	32	33	58	15½
50	5.49	139.96	33	32½	59	15
60	5.38	136.07	34	31¾	60	14½
70	5.32	131.27	35	31	61	14
80	5.29	127.54	36	30½	62	13½
90	5.29	127.54	37	29¾	63	13
			38	29	64	12½
			39	28¼	65	11¾
			40	27¾	66	11¼
Mean		103.66	41	27	67	10¾
			42	26½	68	10¼
			43	25¾	69	9¾
			44	25¼	70	9¼
			45	24½		

CARRYING CAPACITY OF A TEN TON FREIGHT CAR.

Whiskey.....60 barrels	Lumber .. ..6,000 feet
Salt.....70 barrels	Barley .....300 bushels
Lime .....70 barrels	Wheat .....340 bushels
Flour .....90 barrels	Flax Seed.....360 bushels
Eggs .....130 to 160 barrels	Apples.....370 bushels
Flour .....200 sacks	Corn .....400 bushels
Wood..... 6 cords	Potatoes.....430 bushels
Cattle .....18 to 20 head	Oats .....680 bushels
Hogs .....50 to 60 head	Bran .....1,000 bushels
Sheep .....86 to 100 head	Butter .....20,000 pounds

POPULATION OF THE LARGER CITIES.

OFFICIAL CENSUS OF 1890.

New York, N. Y.	1,513,501	Lincoln, Neb.	55,491
Chicago, Ill.	1,098,576	Charleston, S. C.	54,592
Philadelphia, Pa.	1,044,894	Hartford, Conn.	53,182
St. Louis, Mo.	460,357	St. Joseph, Mo.	52,811
Brooklyn, N. Y.	806,343	Evansville, Ind.	50,674
Boston, Mass.	446,507	Los Angeles, Cal.	50,394
Baltimore, Md.	434,151	Des Moines, Ia.	50,067
San Francisco, Cal.	297,990	Bridgeport, Conn.	48,856
Cincinnati, O.	296,308	Oakland, Cal.	48,590
Cleveland, O.	251,546	Portland, Ore.	48,294
Buffalo, N. Y.	254,457	Saginaw, Mich.	46,169
New Orleans, La.	241,995	Salt Lake City, Utah.	45,025
Pittsburg, Pa.	238,473	Lawrence, Mass.	44,164
Washington, D. C.	229,796	Springfield, Mass.	44,164
Detroit, Mich.	205,669	Utica, N. Y.	44,001
Milwaukee, Wis.	204,150	Manchester, N. H.	43,983
Newark, N. J.	181,518	Seattle, Wash.	43,914
Minneapolis, Minn.	164,738	Hoboken, N. J.	43,561
Jersey City, N. J.	163,987	Savannah, Ga.	41,762
Louisville, Ky.	161,005	Peoria, Ill.	40,758
Omaha, Neb.	139,526	New Bedford, Mass.	40,705
Rochester, N. Y.	138,327	Harrisburg, Pa.	40,164
St. Paul, Minn.	133,156	Somerville, Mass.	40,117
Kansas City, Mo.	132,416	Erie, Pa.	39,699
Providence, R. I.	132,043	San Antonio, Tex.	38,681
Indianapolis, Ind.	107,445	Kansas City, Kan.	38,170
Allegheny, Pa.	106,967	Dallas, Tex.	38,140
Denver, Col.	106,760	Sioux City, Ia.	37,862
Albany, N. Y.	94,640	Elizabeth, N. J.	37,670
Columbus, O.	90,398	Wilkesbarre, Pa.	37,651
Syracuse, N. Y.	87,877	Covington, Ky.	37,375
Worcester, Mass.	84,536	Portland, Me.	36,608
Scranton, Pa.	83,450	Tacoma, Wash.	35,858
New Haven, Conn.	81,451	Holyoke, Mass.	35,528
Richmond, Va.	80,838	Fort Wayne, Ind.	35,349
Paterson, N. J.	78,358	Norfolk, Va.	35,154
Toledo, O.	78,358	Binghamton, N. Y.	35,093
Lowell, Mass.	77,635	Wheeling, W. Va.	35,052
Nashville, Tenn.	76,309	Youngstown, O.	33,199
Fall River, Mass.	74,351	Augusta, Ga.	33,150
Cambridge, Mass.	69,837	Duluth, Minn.	32,725
Atlanta, Ga.	65,514	Springfield, Ill.	32,135
Memphis, Tenn.	64,586	Lancaster, Pa.	32,090
Grand Rapids, Mich.	64,147	Yonkers, N. Y.	31,945
Wilmington, Del.	61,437	Mobile, Ala.	31,822
Troy, N. Y.	60,605	Topeka, Kan.	31,809
Reading, Pa.	58,926	Quincy, Ill.	31,478
Dayton, O.	58,868	Salem, Mass.	30,735

Trenton, N. J.....	58,488	Long Island City, N. Y	30,396
Camden, N. J.....	58,274	Terre Haute, Ind.....	30,287
Lynn, Mass.....	55,684		

Geographical Div.	1890.	1880.	1879.
The United States.	62,622,250	50,155,783	38,558,371
North Atlantic Division.....	17,401,545	14,507,407	12,298,730
South Atlantic Division.....	8,857,920	7,597,197	5,853,610
Northern Central Division.....	22,362,279	17,364,111	12,981,111
Southern Central Division....	10,972,893	8,919,371	6,434,410
Western Division.....	3,027,613	1,767,697	990,510

RELATIVE WEIGHTS OF METALS.

The weight of Bar Iron being.....		1.
Cast Iron.....	=	.95
Steel.....	=	1.02
Copper.....	=	1.16
Brass.....	=	1.09
Lead.....	=	1.48
The weight of Cast Iron being.....		1.
Bar Iron.....	=	1.07
Steel.....	=	1.08
Brass.....	=	1.16
Copper.....	=	1.21
Lead.....	=	1.56
The weight of Yellow Pine being.....		1.
Cast Iron.....	=	16.
Steel.....	=	17.2
Copper.....	=	19.3
Brass.....	=	18.4
Lead.....	=	24.
The weight of Brass being.....		1.
Bar Iron.....	=	.92
Cast Iron.....	=	.86
Steel.....	=	.93
Copper.....	=	1.05
Lead.....	=	1.35
The weight of Copper being.....		1.
Bar Iron.....	=	.87
Cast Iron.....	=	.82
Steel.....	=	.88
Brass.....	=	.93
Lead.....	=	1.28
The weight of Lead being.....		1.
Bar Iron.....	=	.68
Cast Iron.....	=	.64
Steel.....	=	.69
Brass.....	=	.74
Copper.....	=	.78

THE ENGLISH MILE COMPARED WITH OTHER EUROPEAN MEASURES.

	English Mile.	English Geog M.	French Kilom.	German Geog. M.	Russian Verst.	Austrn. Mile.
English Statute Mile	1·000	0·867	1·609	0·217	1·508	0·212
English Geog. Mill.	1·153	1·000	1·855	0·250	1·738	0·245
Kilometre.....	0·621	0·540	1·000	0·135	0·937	0·132
German Geog. Mile.	4·610	4·000	7·420	1·000	6·953	0·978
Russia Verst.....	0·663	0·575	1·067	0·144	1·000	0·141
Austrian Mile.....	4·714	4·089	7·586	1·022	7·112	1·000
Dutch Ure.....	3·458	3·000	5·565	0·750	5·215	0·734
Norwegian Mile.....	7·021	6·091	11·299	1·523	10·589	1·489
Swedish Mile.....	6·644	5·764	10·692	1·441	10·019	1·409
Danish Mile.....	4·682	4·062	7·536	1·016	7·078	0·994
Swiss Stunde.....	2·987	2·592	4·808	0·648	4·505	0.634

	Dutch Ure.	Norweg. Mile.	Swedish Mile.	Danish Mile.	Swiss Stunde.
English Statute Mile	0·289	0·142	0·151	0·213	0·335
English Geog. Mile.	0·333	0·164	0·169	0·246	0·386
Kilometre.....	0·180	0·088	0·094	0·133	0·208
German Geog. Mile	1·333	0·657	0·694	0·985	1·543
Russian Verst.....	0·192	0·094	0·100	0·142	0·222
Austrian Mile.....	1.363	0·672	0·710	1·006	1·578
Dutch Ure.....	1·000	0·493	0·520	0·738	1·157
Norwegian Mile.....	2·035	1·000	1·057	1·499	2·350
Swedish Mile.....	1·921	0·948	1·000	1·419	2·224
Danish Mile.....	1·354	0·667	0·705	1·000	1·567
Swiss Stunde.....	0·864	0·425	0·449	0·638	1·000

WEIGHT OF A CUBIC FOOT OF VARIOUS SUBSTANCES.

METALS.

Platinum.....	lbs.,	1,218	—oz.,	12		
Pure gold*....	"	1,203	"	10		
Mercury.....	"	848	"	12		
Lead.....	"	709	"	8		
Pure silver†..	"	625	"	13		
Steel.....	"	487	"	12		
Tin.....	lbs.,	455	—oz.,	11		
Cast iron.....	"	450	"	7		
Copper.....	"	547	"	4		
Brass.....	"	543	"	12		
Zinc.....	"	428	"	13		

*The value of a ton of pure gold is $602,799.21. $1,000,000 gold coin weighs 3,685.8 pounds avoirdupois. †The value of a ton of silver is $37,704.84. $1,000,000 silver coin weigh 58,929.9 pounds avoirdupois.

MISCELLANEOUS.

Indian rubber	lbs.,	56	oz., 7	Pressed cotton	lbs., 25 .....
Pressed hay	"	25	.....		

EARTH, STONE, ETC.

Italian marble	lbs.,	169	oz., 4	Mortar	lbs.,	109	oz., 6
Vermont marble	"	165	" 9	Mud	"	101	" 14
Window glass	"	165	" 2	Loose earth	"	93	" 12
Common glass	"	157	" 8	Lehigh coal, loose	"	56	" 4
Moist sand	"	128	" 2	Lackawanna, loose	"	48	" 10
Clay	"	120	" 10				
Brick	"	118	" 12				

WOODS.

Lignum vitæ	lbs.,	83	oz., 5	Shellbark hick'ry	lbs.,	43	oz., 2
Ebony	"	83	" 5	Pitch pine	"	41	" 4
Boxwood	"	75	" 2	Chestnut	"	38	" 2
Mahogany	"	66	" 7	Birch	"	35	" 7
White oak	"	53	" 12	Cedar	"	35	" 1
Ash	"	52	" 13	White poplar	"	33	" 1
Red hickory	"	52	" 6	Spruce	"	31	" 4
Apple	"	49	" 9	Yellow pine	"	28	" 13
Maple	"	46	" 14	Butternut	"	23	" 8
Cherry	"	44	" 11	Cork	"	15	" ..

GROCERIES.

Sugar	lbs.,	100	oz., 5	Butter	lbs.,	58	oz., 14
Beeswax	"	60	" 5	Tallow	"	58	" 13
Lard	"	59	" 3	Castile soap	"	56	" 15

MELTING TEMPERATURE OF ALLOYS.

Lead 1, Tin 1, Bismuth 4,	melts at	155	degrees
Lead 3, Tin 5, Bismuth 8,	"	208	"
Lead 1, Tin 3, Bismuth 5,	"	212	"
Lead 1, Tin 4, Bismuth 5,	"	240	"
Tin 1, Bismuth 1,	"	286	"
Lead 2, Tin 3	"	334	"
Tin 2, Bismuth 1,	"	336	"
Lead 1, Tin 2,	"	360	"
Tin 8, Bismuth 1,	"	392	"
Lead 2, Tin 1,	"	475	"

U. S. MINERAL STATISTICS, 1890.

METALLIC PRODUCTS.	QUANTITY.	VALUE.
Pig iron, long tons	9,202,703	$151,200,410
Silver; troy ounces	54,500,000	70,464,645
Gold, troy ounces	1,588,880	32,845,000
Copper, pounds	265,115,133	30,848,797
Lead, short tons	161,754	14,266,703
Zinc, short tons	63,683	6,266,407
Quicksilver, flasks	22,926	1,203,615
Nickel, pounds	223,488	134,093
Aluminum, and aluminum in alloys, pounds	61,281	61,281
Antimony, short tons	129	40,756
Platinum, troy ounces	600	2,500
Total		$307,334,207

WEIGHT OF LIQUIDS PER GALLON.

Sulphuric acid	in lbs.	18.5	Whale oil	in lbs.	9.2
Nitric acid	"	12.7	Oil of turpentine	"	8.7
Muriatic acid	"	12.	Petroleum	"	8.8
Alcohol of commerce	"	8.2	Tar	"	10.1
Alcohol proof spirit	"	9.2	Vinegar	"	10.1
Naphtha	"	8.5	Water distilled	"	10.
Linseed oil	"	9.4	Salt water	"	10.3

THE EFFECT OF HEAT ON VARIOUS SUBSTANCES.

Antimony melts at	951.	deg.	Zinc melts at	740.	deg.
Bismuth "	476.	"	Ice "	32.	"
Brass "	1900.	"	Mercury boils at	662.	"
Copper "	2548.	"	Naphtha "	186.	"
Glass "	2377.	"	Fresh water boils at	212.	"
Gold "	2590.	"	Sea water "	213.2	"
Cast Iron "	3479.	"	Ether "	100.	"
Lead "	594.	"			

WEIGHT OF WATER AT DIFFERENT TEMPERATURES.

Temperature, Fahr.	Weight in Pounds per Cubic Foot	Temperature, Fahr.	Weight in Pounds per Cubic Foot.
32	62.417	70	62.302
40	62.423	80	62.218
50	62.409	90	62.119
60	62.367	212	59.700

WEIGHT AND SPECIFIC GRAVITIES OF LIQUIDS.

Liquids at 32 deg. Fahr.	Weight of one cubic foot.	Weight of one gallon	Specific gravity.
	Pounds.	Pounds.	Water=1.
Mercury	848.7	136.0	13.596
Bromine	185.1	29.7	2.966
Sulphuric acid, max. concentratn.	114.9	18.4	1.84
Nitrous acid	96.8	15.5	1.55
Chloroform	95.5	15.3	1.53
Water of the Dead Sea	77 4	12.4	1.24
Nitric acid, of commerce	76.2	12.2	1.22
Acetic acid, maximum concentratn.	67.4	10.8	1.08
Milk	64.3	10.3	1.06
Sea water, ordinary	64.05	10.5	1.026
Pure water (distild.) at 39 o 1. F.	62.425	10.0	1.000
Wine of Bordeaux	62.1	9.9	0.994
Wine of Burgundy	61.9	9 9	0.991
Linseed oil	58.7	9 4	0.94
Poppy oil	58.1	9.3	0.93
Rape seed oil	57.4	9.2	0.92
Whale oil	57.4	9.2	0.92
Olive oil	57.1	9.15	0.915
Turpentine oil	54.3	8.7	0.87
Potato oil	51 2	8.2	0.82
Petroleum	54.9	8.8	0.88
Naphtha	53.1	8.5	0.85
Ether, nitric	69 3	11.1	1.11
" sulphurous	67.4	10.8	1.08
" nitrous	55.6	8.9	0.89
" acetic	55.6	8.9	0.89
" hydrochloric	54.3	8.7	0.87
" sulphuric	44.9	7.2	0.72
Alcohol, proof spirit	57.4	9.2	0.92
Alcohol, pure	49.3	7.9	0.79
Benzine	53.1	8.5	0.85
Wood spirit	49.9	8.0	0.80

POPULATION OF THE UNITED STATES BY STATES.

		1890.	1880.	1870.
Maine	North Atlantic Div.	661,086	648,936	626,915
New Hampshire		376,530	346,991	318,300
Vermont		332,422	332,286	330,551
Massachusetts		2,238,943	1,783,085	1,457,351
Rhode Island		345,506	276,531	217,353
Connecticut		746,258	622,700	537,454
New York		5,997,853	5,082,871	4,382,759
New Jersey		1,444,933	1,131,116	906,096
Pennsylvania		5,258,014	4,282,891	3,521,951
Delaware	South Atlantic Div.	168,493	146,608	125,015
Maryland		1,042,390	934,943	780.894
District of Columbia		230,392	177,624	131,700
Virginia		1,655,980	1,512,565	1,225,163
West Virginia		762,794	618,457	442,014
North Carolina		1,617,947	1,399,750	1,071,361
South Carolina		1,151,149	995,577	705,606
Georgia		1,837,353	1,542,180	1,184,109
Florida		391,422	269,493	187,748
Ohio	Northern Central Div.	3,672,316	3,198,062	2,665,260
Indiana		2,192,404	1,978,301	1,680,637
Illinois		3,826,351	3,077,871	2,539,891
Michigan		2,093,889	1,636,937	1,184,059
Wisconsin		1,686,880	1,315,497	1,054,670
Minnesota		1,301,826	780,773	439,706
Iowa		1,911,896	1,624,615	1,194,020
Missouri		2,679,184	2,168,380	1,721,295
North Dakota		182,719	36,909	14,181
South Dakota		328,808	98,268	
Nebraska		1,058,910	452,402	122,993
Kansas		1,427,096	996,096	484,471
Kentucky	So. Central Div.	1,858,635	1,648,690	1,321,011
Tennessee		1,767,518	1,542,359	1,258,520
Alabama		1,513,017	1,262,505	996,992
Mississippi		1,289,600	1,131,597	827,922
Louisiana		1,118,587	939,946	726,915
Texas		2,235,523	1,591,749	818,579
Oklahoma		61,834	.....	.....
Arkansas		1,128,179	802,525	4,47148

POPULATION OF THE UNITED STATES BY STATES.

(CONTINUED.)

		1890.	1880.	1870.
Montana	Western Division.	132,159	39,159	20,595
Wyoming		60,705	20,789	9,118
Colorado		412,198	194,327	39,864
New Mexico		153,593	119,565	91,874
Arizona		59,620	40,440	9,658
Utah		207,905	143,963	86,786
Nevada		45,761	62,266	42,491
Idaho		84,385	32,610	14,999
Washington		349,390	75,116	23,955
Oregon		313,767	174,768	90,923
California		1,208,130	864,694	560,247

TWELVE O'CLOCK NOON GREENWICH MEAN TIME.

AS COMPARED WITH THE CLOCK IN THE FOLLOWING PLACES:

	H.	M.			H.	M.	
Boston, U.S.	7	16	A.M.	Quebec	7	15	A.M.
Chicago	6	8	A.M.	San Francisco Port	4	23	A.M.
Dublin	11	35	A.M.	Toronto	6	42	A.M.
Edinburgh	11	47	A.M.	Vancouver	3	38	A.M.
Glasgow	11	43	A.M.	Adelaide	9	14	P.M.
Lisbon	11	23	A.M.	Auckland, N. Z	11	39	P.M.
Madrid	11	45	A.M.	Berlin	0	54	P.M.
Newfoundland, St. Jns	8	29	A.M.	Berne	0	30	P.M.
New York	7	4	A.M.	Bombay	4	51	P.M.
Penzance	11	37	A.M.	Brisbane, Queensland	10	12	P.M.
Philadelphia	6	59	A.M.	Brussels	0	17	P.M.
Calcutta	5	53	P.M.	Pekin	7	46	P.M.
Cape of Good Hope	1	14	P.M.	Perth, W. Australia	8	44	P.M.
Constantinople	1	56	P.M.	Port Moresby	2	40	P.M.
Florence	0	45	P.M.	Prague	0	58	P.M.
Hobart, Tasmania	9	49	P.M.	Rome	0	50	P.M.
Jerusalem	2	21	P.M.	Rotterdam	0	18	P.M.
Madras	5	21	P.M.	St. Petersburg	2	1	P.M.
Malta	0	58	P.M.	Stockholm	1	12	P.M.
Melbourne, Australia	9	40	P.M.	Suez	2	10	P.M.
Moscow	2	30	P.M.	Sydney	10	5	P.E.
Paris	0	9	P.M.	Vienna	1	6	P.M.

Variation of Time depends upon Longitude; every degree east of Greenwich is four minutes earlier, and every degree west four minutes later. Note the variations in the United States or in British America.

SPECIFIC GRAVITIES AND WEIGHTS OF STONES, ETC.

Stones, Earths, Etc.	Specific Gravity.	Weight of a cubic ft. in lbs. Avoir.	Stones, Earths, Etc.	Specific Gravity.	Weight of a cubic ft. in lbs. Avoir.
Amber	1.078	67	Glass, white flint	3.	188
Asbestos	2.996	187	Glass, plate	2.94	184
Asphalte, gritted	2.5	156	Glass, crown	2.53	158
Basalt	2.864	180	Granite	2.625	164
Bathstone	1.97	123	Gypsum	2.28	140
Bermuda stone, hard	2.62	164	Jargon, Ceylon	4.416	276
Bermuda stone, soft	1.47	92	Kentish rag	2.66	166
Beryl, Oriental	3.549	221	Lime, Chalk, ground	.83	52
Bitumen	1.	62	Limestone, lias	2.5	156
Brick, common stock	1.8	115	" magnesian	2.3	144
Brick, red facing	2.	130	Marble (average)	2.7	170
Brick, fire	2.4	150	Marl	1.9	120
Cement, Portland	1.2	87	Masonry, rubble	2.2	140
Cement, Roman	.9	60	" ashlar, Port'd	2.2	140
Chalk, solid	1.8	112	" " granite	2.5	160
	2.8	175	Millstone	2.5	155
Chalk in lumps	...	87	Mortar, old	1.4	90
Clay, potters'	1.9	120	Mortar, new	1.7	110
Clay with gravel	2.	130	Mud	1.63	102
Clay, ordinary	1.9	120	Opal	2.114	132
Coal, anthracite	1.602	100	Peat, hard	1.3	83
Coal, bituminous	1.24	77	Pitch	1.1	79
	1.44	90	Quartz	2.64	166
Coke	.7	47	Rotten stone	2.	124
Concrete	1.9	120	Sand, river	1.9	118
Concrete, lime	1.8	118	Sandstone	2.3	145
Coral	2.68	167	Shale	2.6	162
Crystal, rock	2.653	165	Shingle	...	95
Diamond	3.536	221	Slate	2.9	181
Emerald, Peru	2.775	173	Slates, Cornish	2.5	160
Emery	4.	250	Spar	2.594	162
Feldspar	2.6	162	Sulphur, melted	2.	124
Flint	2.594	162	Tiles, average	1.8	115
Freestone, hewn	2.2	140	Topaz	3.8	237
			Trap	2.7	172
			White lead	3.16	197

CHAPTER IV.

TABLES OF MEASURES, ETC.

DIMENSIONS OF ONE ACRE.

A square, whose sides are 12,649 rods, or 69.57 rods, or 208.71 feet long, contains one acre. Table of dimensions of rectangle containing one acre:

RODS.

1 × 160	1½×106⅔	2×80	2½×64
3 × 53⅓	3½× 45 5-7	4×40	4½×35 5-9
5 × 32	5½× 29 1-11	6×26⅔	6½×24 8-13
7 × 22 6-7	7½× 21⅓	8×20	8½×18 14-17
9 × 17 7-9	9½× 16 16-19	10×16	10½×15 5-21
11 × 14 6-11	11½× 13 7-11	12×13⅓	12½×12 4-5
.....	.....	.....	12 13-20×12 13-20

TO COMPUTE THE VOLUME OF BRICKS, AND THE NUMBER IN A CUBIC FOOT OF MASONRY.

Rule.—To the face dimensions of the particular bricks used, add one half of the thickness of the mortar or the cement in which they are laid and compute the area; divide the width of the wall by the number of brick of which it is composed; multiply this area by the quotient thus obtained, and the product will give the volume of the mass of brick and its mortar in inches. Divide 1,728 by this volume, and the quotient will give the number of bricks in a cubic foot.

Example.—The width of a wall is to be 12¾ inches, and the front of it laid with Philadelphia brick in courses ¼ of an inch in depth; how many bricks will there be in face and backing in a cubic foot? Proceed thus:

Philadelphia front brick 8½×2⅜.

We first reduce all our common fractions to decimals.

Then 8.25+.25×2÷2=8.5 length of brick and joint.

Again, 2.375+.25×2÷2=2.625 width of brick and joint.

Then, 8.5×2.625=22.3125 inches area of face.

Then, 12.75÷3 (number of bricks in width of wall)=4.25 inches.

Hence, 22.3125×4.25=94.83 cubic feet.

And 1728÷94.83=18.22, number of bricks in a cubic foot.

RULE TO FIND THE NUMBER OF GALLONS CONTAINED IN A CAN.

Multiply the diameter by the diameter and then the height. Then multiply by .0034 which will give the number of gallons. Example:

6″ diameter
6″ "

36
8″ high

288
.0034

1152
864

97.92

There is the old rule—instead of .0034 multiply by .7854 and divide by 231″.

RULE TO FIND THE HORSE-POWER OF A STATIONARY ENGINE.

Multiply the area of the piston by the average pressure in pounds per square inch. Multiply this product by the travel of the piston in feet per minute; divide by 33000, this will give the horse-power. Proper example:

Diameter of cylinder,

12
12

144
7854

1130976

BOARD AND TIMBER MEASURE.

Rule.—Multiply the length by the breadth, and the product will give the surface required.

If the dimensions are given in inches, multiply as above and divide by 12. When all the dimensions are in inches, multiply as before and divide the product by 144.

Example.—What are the number of square feet in a board 15 feet in length and 16 inches in width?

$15 \times 16 = 240 \div 12 = 20$ feet.

ESTIMATES OF MATERIALS.

3½ barrels of lime will do 100 sq. yards plastering, two coats.
2 " " " 100 " " one coat.
1½ bushels of hair " 100 " "
1¼ yards good sand " 100 " "
⅓ barrel plaster (stucco), will hard finish 100 square yards plastering.
1 barrel of lime will lay 1,000 brick. It takes good lime to do it.
2 " " 1 cord rubble stone.
½ " " 1 perch " (es. ¼ c'd to perch.)

To every barrel of lime estimate about ⅝ yards of good sand for plastering and brick work.

TABLES CONVENIENT FOR TAKING INSIDE DIMENSIONS.

A box 24 in.x24 in.x14.7 in. will hold a barrel of 31½ gallons.
A box 15 in.x14 in.x11 in. will hold 10 gallons.
A box 8¼ in.x7 in.x4 in. will hold a gallon.
A box 4 in.x4 in.x3.6 in. will hold a quart.
A box 24 in.x28 in x16 in will hold five bushels.
A box 16 in x12 in.x11.2 in. will hold a bushel.
A box 12 in.x11.2 in. x 8 in. will hold a half bushel.
A box 7 in.x6.4 inx12 in. will hold a peck..
A box 8 4 in.x8 in.x4 in. will hold a half peck, or four dry quarts.
A box 6 inx5 3-5 in. and 4 in deep will hold a half gallon.
A box 4 in.x4 in. and 2 1-10 deep will hold a pint.

LAND MEASURE.

To find the number of acres in a body of land, multiply the length by the width (in rods), and divide the product by 160. When the opposite sides are unequal, add them, and take half the sum for the mean length or width.

Find how many acres in a field, 96 rods long and 40 rods wide at one end and 45 at the other. Ans. 25½ acres.

2)85 = 40 × 45 96 length.
42½
42½ mean width,
160)4080(25½ acres.

CIRCULAR MEASURE.

The Diameter is a straight line passing through the centre from opposite parts of the Circumference, or Perimeter.

The Radius is half the Diameter, or a straight line from the centre to the Circumference.

The Diameter is to the Circumference about as 7 is to 22, or more nearly as 1 is to 3·1416.

The Diameter × 3·1416 gives the Circumference.

The Radius squared × 3·1416 gives the Area.

The Diameter squared × 3·1416 gives the Area of a Sphere or Globe.

One-sixth of the Cube of the Diameter × 3·1416 gives the Solidity of a Sphere.

A Circular Acre is 235·504 feet, a Circular Rood 117·752 feet in Diameter. The Circumference of the Globe is about 24,855 miles, and the Diameter about 7,900 miles.

CARPENTERS', BRICKLAYERS' AND BUILDERS' MEASUREMENTS.

Stock or kiln bricks	8¾	inches	×4¼×2¾
Welsh fire-bricks	9	"	×4½×2½
Paving bricks	9	"	×4½×1¾
Square tiles	9¾	"	×9¾×1
"	6	"	×6 ×1
Dutch clinker bricks	9¼	"	×3 ×1½

A Rod of Brickwork 16½ feet × 16½ feet × 1½ brick thick = 306 cubic feet, or 11⅓ cubic yards, and contains about 4,500 bricks with about 75 cubic feet of mortar.

A Square of Flooring is 100 square feet.

Ordinary bricks weigh about 7 lbs. each; a load of 500 weigh over 1½ tons.

EAR CORN MEASURE.

To find the contents of a corn crib multiply the cubic feet by 4 and divide the product by 9.*

Find the contents of a corn crib 18 feet long, 7 feet wide and 8 feet high.

7×8×18=1,008 cu. ft.
4
9)4032
Ans. 448 bus.

*This allows 2¼ cubic feet for a bus. It is the rule most generally used, and will hold out in ordinary good corn, even if measured at the time it is cribbed.

MEASURES OF LENGTH.

Inch, *in* ..... = 72 Points, or 12 Lines.
Nail, 1-16..... = 2¼ Inches.
Palm..... = 3 Inches.
Hand ..... = 4 Inches.
Link ..... = 7·92 Inches.
Quarter (or a Span) ..... = 9 Inches.
Foot ..... = 12 Inches.
Cubit..... = 18 Inches.
Yard..... = 36 Inches.
Pace, Military ..... = 2 Feet 6 Inches.
Pace, Geometrical ..... = 5 Feet.
Fathom ..... = 6 Feet.
Rod, Pole, or Perch..... = 5½ Yards.
Chain (100 Links)..... = 22 Yards (4 Poles).
Cable's Length ..... = 120 Fathoms, 720 Feet.
Furlong ..... = 40 Rods, 220 Yards.
Mile ..... = 8 Furlongs, 80 Chains, 320 Rods, 1,760 Yards, 5,280 Feet, 63,360 Inches.

Mile, Geographical, or Nautical Knot = 6,082·66 Feet.

Admiralty Knot or Nautical Mile, 6,080 Feet = 1·151 Mile Statute Degree.

League = 3 Miles.

Degree = 60 Geographical, or 69·121 Statute Miles.

WATER.

Cubic inch..... = ·0361 lb.
Gallon..... = 10·0000 "
35·943 cubic feet (210 gallons) = 1 ton.

The gallon is = 277¼ cubic inches, = 0·16 cubic feet, = 10 lb. distilled water.

Water for Ships: Ton 210 gals., Butt 110, Puncheon 72, Barrel 36, Kilderkin 18.

Cisterns: 1 cubic foot, is equal to about 6¼ gallons, or 62·321 lb. A cistern 4 feet by 2½ and 3 deep will hold about 187 gallons, and weigh nearly 16 cwt. in additjon to its own weight.

COMPARATIVE TABLE OF WEIGHTS.

	Troy.	Apothecaries.	Avoirdupois.
1 lb. equals	5,760 grains,	equals 5,760 grains,	equals 7,000 grains.
1 oz. "	480 "	" 480 "	" 437·5 "
	175 lbs.	" 175 lbs.	" 144 lbs.

The half peck, or dry gallon, contains 268.8 cubic inches. Six quarts, dry measure, are equal to nearly 7 quarts liquid measure.

CISTERN MEASURE.

To find the capacity of a round cistern or tank, multiply the square of the average diameter by the depth, and take 3-16 of the product. For great accuracy, multiply by 1865 instead of taking 3-16.

For square cisterns or tanks, multiply the cubic feet by .2⅜ (tenths).

Find the capacity of a round cistern, 6 feet in diameter and 8 feet in deep.

$$6 \times 6 \times 8 = 288$$
$$3$$
$$16)864(54 \text{ barrels.}$$

Ans. 54 barrels of 31½ gallons.

How many barrels will a square tank hold, 10 feet long, 7 feet wide, and 6 feet deep?

$6 \times 7 \times 10 = 420$ (cubic feet) $\times$ 2⅜ = 99¾ barrels. Ans.

GRAIN MEASURE.

To find the capacity of a bin or wagon-bed; multiply the cubic feet by .8 (tenths). For great accuracy, add ⅓ of a bushel for every 100 cubic feet.

To find the cubic feet, multiply the length, width and depth together.

Find the capacity of a bin 4 ft. wide, 5 ft. deep and 15 ft. long.

$4 \times 5 \times 15 = 300$ cubic ft.
.8

Ans. 240.0 bus.

To get the exact ans. 1 bu. is added for the 300 cu. ft.

240 + 1 = 241 bus. exact ans.

How many bus. will a wagon bed hold, 10 ft. long, 3 ft. wide, 18 in. or 1½ ft. deep?

A bed 10 ft. long and 3 ft. wide, will hold 2 bus. for every inch in depth.

$1\frac{1}{2} \times 3 \times 10 = 45$ cubic feet.
.8

Ans. 36.0 bus.

HAY MEASURE.

About 500 cubic feet of well settled hay, or about 700 of new mown hay, will make a ton. To estimate amount of hay in mow—Ten cubic yards of meadow hay weigh a ton. When the hay is taken out of old stacks, 8 or 9 yards will make a ton. Eleven or twelve cubic yards of clover, when dry, make a ton.

TO FIND THE CONTENTS OF A CORN CRIB.

Multiply the number of cubic feet by 4½ and point off one decimal place; the result will be the answer in bushels. How many bushels will a crib hold that is 48 feet long, 7½ feet wide, and 8½ feet high? 48×7½×8½=3,060 cubic feet; 3,060×4½=13,770, Ans.

CUBIC OR SOLID MEASURE.

Cubic Foot .....=1,728 Cubic Inches.
Cubic Yard.....=27 Cubic Feet, 21 033 bushels.
Stack of Wood .....=108 Cubic Feet.
Shipping Ton.....=40 Cubic Feet Merchandise.
Shipping Ton.....=42 Cubic Feet of Timber.
Ton of displacement of a ship... =35 Cubic Feet.

LIQUID MEASURE.

The United States standard for measurement of all liquid is the "wine" or "Winchester" gallon, containing 231 cubic inches.

4 gills make one pint.
2 pints " quart.
4 quarts " gallon.
31½ gallons make one barrel.
2 barrels make one hogshead.

MEASURE OF WEIGHT.

The Pound is the United States standard of weight as applied to general purposes, and is the weight of 27·7015 cubic inches of distilled water, at its greatest density (*i. e.* at 39.83° Fahrenheit, the barometer being at 30 inches), and is equivalent to 1000 Troy grains.

27 11-32 grains make one dram.
16 drams " ounce.
16 ounces " pound.
25 lbs. make one quarter.
4 quarters make one cwt.
20 cwt. " ton.

In some cases the following table for gross weight is used: 28 lb.=1 quar.; 4 quar.=1 cwt.; 20 cwt., or 2240 lbs.=1 ton.

THE METRIC SYSTEM.

The metric system is a system of weights and measures based upon a unit called a meter.

The *meter* is one ten-millionth part of the distance from the equator to either Pole, measured on the earth's surface at the level of the sea,

The *names* of derived metric denominations are formed by prefixing to the name of the primary unit of a measure—

Milli (mill'e), a thousandth,	Hecto (hek'to), one hundred.
Centi (sent'e), a hundredth,	Kilo (kil'o), a thousand.
Deci (des'e), a tenth,	Myria (mir'ea), ten thousand.
Deka (dek'a), ten,	

This system, first adopted by France, has been extensively adopted by other countries, and is much used in the sciences and the arts. It was legalized in 1866 by Congress to be used in the United States, and is already employed by the Coast Survey, and to some extent, by the Mint and the General Postoffice.

Linear Measures.

The *meter* is the primary unit of lengths.

10 millimeters (mm.)....=1 centimeter (cm.)....= 0.3937 in.
10 centimeters.....=1 decimeter.....= 3.937 in.
10 decimeters.....=1 METER .....= 39.37 in.
10 meters .....=1 dekameter .....=393.37 in.
10 dekameters.....=1 hectometer .....=328 ft. 1 in.
10 hectometers.....=1 KILOMETER (km.)..= 0.62137 mi.
10 kilometers .....=1 myriameter.....= 6.2137 mi.

The *meter* is used in ordinary measurements; the *centimeter* or *millimeter*, in reckoning very small distances; and the *kilometer* for roads or great distances.

A *centimeter* is about ⅜ of an inch; a *meter* is about 3 feet 3 inches and ⅜; a *kilometer* is about 200 rods, or ⅝ of a mile.

Surface Measures.

The *square meter* is the primary unit of ordinary surfaces.

The *are* (air), a square, each of whose sides is ten *meters*, is the unit of land measures.

100 square millimeters (sq. mm.)=1 square centimeter (sq. cm.) ..... } =0.155 sq. inch.
100 square centimeters..=1 square decimeter..=15.5 sq. inches.
100 square decimeters=1 square METER (sq. m.) ..... } =1550 sq. in., or 1.196 sq. yds.
100 centiares, or sq. meters.....=1 ARE (ar.) .....=119.6 sq. yds.
100 ares .....=1 hectare (ha.)..=2.471 acres.

A *square meter*, or one *centiare*, is about 10¾ square feet, or 3 square yards, and a *hectare* is about 2½ acres.

Cubic Measures.

The *cubic meter* or *stere* (stair), is the primary unit of a volume.

1000 cubic millimeters (cu. mm.)=1 cubic centimeter (cu. cm.)=[0.061 cubic inch.

1000 cubic centimeters=1 cubic decimeter=61.022 cubic inches.

1000 cubic decimeters.=1 cubic METER (cu. m.)=35.314 cu. ft.

The *stere* is the name given to the cubic meter in measuring wood and timber. A tenth of a stere is a *decistere*, and ten steres are a *dekastere*.

A *cubic meter*, or *stere*, is about 1⅓ cubic yards, or about 2 1-5 cord feet.

Liquid and Dry Measures.

The *liter* (leeter) is the primary unit of measures of capacity and is a cube, each of whose edges is a tenth of a meter in length.

The *hectoliter* is the unit in measuring large quantities of grain, fruits, roots and liquids.

10 millimeters (ml.).=1 centiliter (cl.)....=0.338 fluid ounce.
10 centiliters ..... =1 deciliter .....=0.845 liquid gill.
10 deciliters .....=1 LITER (l.).....=1.0567 liquid quarts.
10 liters.....=1 dekaliter .....=2.6417 gallons.
10 dekaliters .....=1 HECTOLITER (hl.)=2 bushels 3.35 pecks.
10 hectoliters.....=1 kiloliter .....=28 bushels 1½ pecks.

A *centiliter* is about ⅓ of a fluid ounce; a *liter* is about 1 1-18 liquid quarts, or 9-10 of a dry quart; a *hectoliter* is about 2 5-6 bushels; and a *kiloliter* is one cubic meter, or stere.

Weights.

The *gram* is the primary unit of weights, and is the weight in a vacuum of a cubic centimeter of distilled water at the temperature of 39.2 degrees Fahrenheit.

10 milligrams (mg.)	= 1 centigram ..... =	0.1543	troy grain.
10 centigrams.....	= 1 decigram..... =	1.543	troy grains.
10 decigrams.....	= 1 GRAM (g.) ..... =	15.432	troy grains.
10 grams	= 1 dekagram ..... =	0.3527	avoir. oz.
10 dekagrams.....	= 1 hectogram..... =	3.5274	avoir. ozs.
10 hectograms	= 1 KILOGRAM (k.).. =	2.2046	avoir. lbs.
10 kilograms.....	= 1 myriagram ..... =	22.046	avoir. lbs.
10 myriagrams....	= 1 quintal ..... =	220.46	avoir. lbs.
10 quintals.....	= 1 TONNEAU (t.) ... =	2204.6	avoir. lbs.

The *gram* is used in weighing gold, jewels, letters, and small quantities of things. The *kilogram*, or, for brevity, *kilo*, is used by grocers; and the *tonneau* (tonno), or *metric ton*, is used in finding the weight of very heavy articles.

A *gram* is about 15½ grains troy; the *kilo* about 2½ pounds avoirdupois; and the *metric ton*, about 2205 pounds.

A *kilo* is the weight of a liter of water at its greatest density; and the *metric ton*, of a cubic meter of water.

Metric numbers are written with the decimal-point (.) at the right of the figures denoting the unit; thus, 15 meters and 3 centimeters are written, 15.03 m.

When metric numbers are expressed by figures, the part of the expression at the left of the decimal-point is read as the number of the unit, and the part at the right, if any, as a number of the lowest denomination indicated, or as a decimal part of the unit; thus, 46.525 m. is read 46 meters and 525 millimeters, or 46 and 525 thousandths meters.

In writing and reading metric numbers, according as the scale is 10, 100, or 1000, each denomination should be allowed one, two, or three orders of figures.

SCRIPTURE AND ANCIENT WEIGHTS AND MEASURES.

Scripture Long Measures.

	Inches.		Feet.	Inches.
Digit	= 0.912	Cubit	= 1	9.888
Palm	= 3.648	Fathom	= 7	3.552
Span	= 10.944			

Egyptian Long Measures.

Nahud cubit.. = 1 foot 5.71 in. | Royal cubit.. = 1 foot 8.66 in.

Grecian Long Measures.

	Feet.	Inches.		Feet.	Inches
Digit	=	0.7554	Stadium	= 604	4.5
Pous (foot)	= 1	0.0875	Mile	= 4835	
Cubit	= 1	1.5984⅜			

Roman Long Measures.

	Inches.		Feet.	Inches.
Digit..... =	0.72575	Cubit ..... =	1	5.406
Uncia (inch)..... =	0.967	Passus ..... =	4	10.02
Pes (foot)..... =	11.604	Mile (millar'm) =	4842	

Ancient Weights.

	Troy Grains.		Troy Grains.
Attic obolus..... =	8.2 9.1	Alexandrian mina =	9.992
Attic drachma .... =	51.9 54.6 69	Denarius (Roman) =	61.9 62.5
Egyptian mina.... =	8.326	Denarius Nero... =	54
Ptolemaic mina ... =	8.985	Ounce ..... =	415.1 437.2 431.2
Lesser mina..... =	3 892	Drachm ..... =	146.5

Greater mina ..... = 1-10 of drachma.
Talent .... = 60 minæ = 56 pounds avoirdupois.
Pound..... = 12 Roman ounces.

In this last table, where two or more values are given for the same weight, they are from different authorities on the subject.

USEFUL RULES IN MENSURATION.

To find the circumference of a circle, the diameter being given.

Multiply the diameter by 3 1-7. In other words, multiply the diameter by 22 and divide by 7.

Or, should closer accuracy be required, multiply the diameter by 3·1416.

Example I.—The diameter of a circle is 8 inches; to find the circumference.

8 × 22 = 176, which divided by 7 gives 25 1-7 inches, the circumference required.

Or, 8 × 3·1416 ÷ 25·13 inches.

To find the area of a circle, the diameter being given.

Multiply one-quarter of the diameter, or, which is the same thing, half the radius, by the circumference.

Example II.—The diameter of a circle is 8 inches; to find its area.

L. of C.

One-quarter of the diameter is 2 inches; the circumference is 25 1-7 inches.

$2 \times 25\ 1\text{-}7 = 50\ 2\text{-}7$ square inches, the area required.

To find the area of an ellipse, the axes being given.

Multiply the axes together, and multiply the result by ·7854.

Example III.—The major axis of an ellipse is 6 inches and the minor 4 inches; to find its area.

$6 \times 4 = 24$, which multiplied by ·7854, gives 18·85 square inches nearly.

To find the area of a rectangle.

Multiply the length by the breadth.

Example IV.—The length of a rectangle is 16 inches and the breadth 9 inches; to find its area.

$16 \times 9 = 144$ square inches, that is, one square foot the area required.

To find the volume of a circular, elliptical, rectangular, or other tank, or vessel, of which the sides are perpendicular to the base.

Multiply the area of the base by the height.

If the answer is required in cubic inches, all the dimensions must be multiplied in inches. If in cubic feet, the dimensions must be in feet. (See Examples.)

Example Va.—The height of a circular tank is 6 feet, and the diameter of the base 8 feet; to find its volume.

By Example II. the area of the base is 50 2-7 square feet, which multiplied by 6 feet gives 301 5-7 cubic feet, the volume required.

Example Vb.—The height of an elliptical tank is 1 foot 6 inches, the base is 6 inches by 4 inches; to find its volume.

By Example III. the area of the base is 18·85 square inches, which multiplied by 18 inches (that is to say, by the height in inches, as the answer is to be in cubic inches) gives 339·3 cubic inches, the volume required.

Example Vc.—The height of a rectangular vessel is 2 feet 3 inches, the length 1 foot 4 inches, and the breadth 9 inches; to find its volume.

We will suppose the answer is required in cubic feet. This being so, it is in feet that the dimensions must be multiplied. Stated in feet, the height is 2¼ feet, the length 1⅓ feet, and the breadth ¾ foot.

By Example IV. the area of the base is 1⅓ feet multiplied by ¾ foot, that is, is 4-3×¾=12-12=1 square foot, which multiplied by 2¼ feet gives 2¼ cubic feet, the volume required.

To find the volume of a right cone.

Multiply the area of the base by the height and divide by 3.

Example VI.—The height of a cone is 6 inches, and the diameter of the base 3½ inches to find the volume.

The circumference of the base is $\frac{3\frac{1}{2}\times 22}{7}$=11 inches.

The area of the base is one-half of 1½ inches (the radius) ×11=⅞×11=74-8=9⅝ square inches.

And the area 9⅝×6 inches (the height)=57½, which divided by 3 gives 19¼ cubic inches, the volume required.

To find the volume of a frustum of a right cone.

From the volume of the complete cone of which the frustum is a part subtract the volume of the cone cut off.

For example, the volume of the frustum C A B D is equal to the volume of the complete cone O A B less the volume of O C D the cone cut off.

The height of the complete cone and that of the cone cut off from it to form the frustum can be found by Problem V.

To find the volume of a sphere, the diameter being given.

Multiply the diameter of the sphere by the area of a circle of same diameter, and take two-thirds of the product.

Example VII.—The diameter of a sphere is 8 inches. The area of a circle of same diameter is 50 2-7 (see Example II.); which multiplied by 8 gives 402 2-7 cubic inches, two-thirds of which (268 1-5 about) is the volume required.

Or, Multiply the cube of the diameter by ·5236.

Given the volume of a vessel, any vessel, to find the number of gallons, quarts, or pints that it will hold.

If the volume is in cubic feet, as in Example V *a*, then, to bring it to gallons, multiply by 6¼, there being in a cubic foot of water 6¼ gallons, about. If the volume is in cubic inches, divide by 277. The number of cubic inches in a gallon of water is 277¼ nearly; but in ordinary calculations, the quarter may be omitted.

If the volume is required in quarts, multiply it, if in cubic feet, by 25; if in cubic inches, divide it by 69. The number of cubic inches in a quart of water is about 69¼; in our examples here we have disregarded the fraction.

If the volume is required in pints, multiply it, if in cubic feet, by 50; if in cubic inches, divide it by 35. The number of cubic inches in a pint of water is rather more than 34½; in our examples we have taken it as 35.

Example VIII.—To find the number of gallons, quarts, or pints, contained in the tank of Example V*a*.

Gallons.—301 5-7×6¼=1885 5-7 gallons.

Quarts.—301 5-7×25=7542 6-7 quarts.

Pints.—301 5-7×50=15085 5-7 pints.

Example IX.—To find the number of gallons, quarts, or pints, contained in the tank of Example V*b*.

Gallons.—339·3÷277=1·22 gallons about.

Quarts.—339·3÷69=4·92 quarts about.

Pints.—339·3÷35=9·7 pints about.

Given the number of gallons, quarts, or pints, that a tank or other vessel contains, any vessel, of which the sides are perpendicular to the base, also the dimensions of the base, to find its height.

Divide the number of gallons by 6¼; this will give the volume of the required tank in cubic feet. If the quantity is given in quarts, then to ascertain the required volume, multiply by 69. If the quantity is given in pints, multiply by 35.

To find the required height for the tank, divide the volume found as just shown, by the area of the base.

CHAPTER V.

USEFUL TABLES FOR TINNERS AND SHEET METAL WORKERS.

WEIGHT OF A LINEAL FOOT OF FLAT BAR IRON, IN LBS.

BIRMINGHAM GAUGE.

Breadth in Inches.	THICKNESS IN FRACTIONS OF INCHES.								
	¼	5-16	⅜	7-16	½	⅝	¾	⅞	1
1	.83	1.04	1.25	1.46	1.67	2.08	2.50	2.92	3.34
1⅛	.93	1.17	1.40	1.64	1.87	2.34	2.81	3.28	3.75
1¼	1.04	1.30	1.56	1.82	2.08	2.60	3.13	3.65	4.17
1⅜	1.14	1.43	1.72	2.00	2.29	2.87	3.44	4.01	4.59
1½	1.25	1.56	1.87	2.19	2.50	3.13	3.75	4.38	5.00
1⅝	1.35	1.69	2.03	2.37	2.71	3.39	4.07	4.70	5.43
1¾	1.46	1.82	2.19	2.55	2.92	3.65	4.38	5.11	5.84
1⅞	1.56	1.95	2.34	2.74	3.13	3.91	4.69	5.47	6.26
2	1.67	2.08	2.50	2 92	3.34	4.17	5.01	5.86	6.68
2⅛	1.77	2.21	2.66	3.10	3.55	4 43	5.32	6.21	7.10
2¼	1.87	2.34	2.81	3.28	3.76	4.69	5 63	6.57	7.52
2⅜	1.98	2.47	2.97	3.47	3 96	4.95	5.95	6.94	7.93
2½	2.08	2.60	3.13	3.65	4.17	5.21	6.26	7.30	8.35
2⅝	2.19	2.74	3.28	3.83	4.38	5.47	6.57	7.67	8.77
2¾	2.29	2.87	3.44	4.01	4.59	5.74	6.88	8.03	9.18
2⅞	2.40	3.00	3.60	4.20	4.80	6.00	7.20	8.40	9.60
3	2.50	3.13	3.75	4.38	5.01	6.26	7.51	8.76	10.02
3¼	2.71	3.39	4.07	4.74	5.43	6.78	8.14	9.49	10.86
3½	2.92	3.65	4.38	5.11	5.84	7.30	8.76	10.23	11.69
3¾	3.13	3.91	4.68	5.47	6.26	7.82	9.39	10.95	12.52
4	3.34	4.17	5.00	5.84	6.68	8.35	10.02	11.69	13.36
4¼	3.54	4.43	5.32	6.21	7.09	8.87	10.64	12.42	14.19
4½	3.75	4.69	5.63	6.57	7.51	9.39	11.27	13.15	15.03
4¾	3.06	4.95	5.94	6.94	7.93	9.91	11.89	13.88	15.86
5	4.17	5.21	6.26	7.30	8.35	10.44	12.52	14.61	16.70
5¼	4.38	5.47	6.57	7.67	8.76	11.96	13.14	15.34	17.53
5½	4.59	5.73	6.88	8.03	9.18	11.48	13.77	16.07	18.37
5¾	4.80	6.00	7.20	8.40	9.60	12.00	14.40	16.80	19.20
6	5.01	6.25	7.51	8.76	10.02	12.53	15.03	17.53	20.05

BAR AND SHEET BRASS--WEIGHT IN POUNDS.

Thickness, or Diameter, or Size; inches.	Sheets per Square foot.	Square bars 1 foot long.	Round bars 1 foot long.	Thickness, or Diameter, or Size; inches.	Sheet per Square foot.	Square bars 1 foot long.	Round bars 1 foot long.
1-16	2.7	.015	.011	1 1-16	45.95	4.07	3.20
1/8	5.41	.055	.045	1/8	49.69	4.55	3.57
3-16	8.12	.125	.1	3-16	51.4	5.08	3.97
1/4	10.76	.225	.175	1/4	54.18	5.65	4.41
5-16	13.47	.350	.275	5-16	56.85	6.22	4.86
3/8	16.25	.51	.395	3/8	59.55	6.31	4.35
7-16	19.	.69	.54	7-16	62.25	7.45	5.85
1/2	21.65	.905	.71	1/2	65.	8.13	6.37
9-16	24.3	1.15	.9	9-16	57.75	8.83	6.92
5/8	27.12	1.4	1.1	5/8	70.35	9.55	7.48
11-16	29.77	1.72	1.35	11 16	73.	10.27	8.05
3/4	32.46	2.05	1.60	3/4	75.86	11.	8.65
13-16	35.18	2.4	1.85	13-16	78.52	11.82	9.29
7/8	37.85	2.75	2.15	7/8	71.25	72.68	9.95
15-16	40.55	3.15	2.48	15-16	84.	13.5	10.58
1	43 29	3.65	2.85	2	86.75	14.35	11.25

SHEET COPPER.

Weight of sheet copper per square foot and per sheet and thickness for American wire gauge.

No. gauge.	Wt. per sq. foot.	14x48 lbs. per sheet.	24x48 lbs. per sheet.	30x60 lbs. per sheet.	36x72 lbs. per sheet.	48x72 lbs. per sheet.
12	3.660		29.280	45.750	65.880	87.840
13	3.259		26.072	40.737	58.662	78.216
14	2.903		23.224	36.287	52.254	69.672
15	2.585		20.680	32.312	46.530	62.040
16	2.302		18.416	28.775	41.436	55.248
17	2.050		16.400	25.625	36.900	49.200
18	1.825		14.600	22.812	32.850	43.800
19	1.625		13.000	20.312	29.850	36.000
20	1.447		11.576	18.087	26.046	34.728
21	1.289		10.312	16.112	23.192	30.936
22	1.148	5.357	9.184	14.360	20.664	27.552
23	1.022	4.769	8.176	12.775	18.396	24,528
24	.910	4.246	7.280	11.375	16.380	21.840
25	.810	3.780	6.480	10.125	14.580	19.440
26	.722	3.369	5.776	9.025	12.996	17.328
27	.643	3.000	5.144	8.037	11.574	15.432
28	.572	2.669	4.576	7.150	10.296	13.728

TINNED SHEATHING COPPER.

Thickness Wire Gauge	Weight per sheet.		Size of Sheet	Weight per Square foot.
No.	Lbs.	Ozs.	Inches.	Ounces.
24	4	9	14x48	14
25	4	4	14x48	17

GUTTER COPPER—20x72 INCHES.

Thickness Wire Gauge	Thickness of 30x60 sheet.		Sheet of same thickness 20x72	
No.	Lbs.	Size.	Lbs.	Ozs.
27	10	30x60	9	2
24	12	30x60	10	8
23	14	30x60	13	2

BAR AND SHEET COPPER.—WEIGHT IN POUNDS.

Thickness, or Diameter, or Size; inches.	Sheets per Square foot.	Square bars 1 foot long.	Square bars 1 foot long.	Thickness, or Diameter or Size; inches.	Sheet per Square foot.	Square bars 1 foot long.	Round bars 1 foot long.
1-16	2.88	015	.011	1 1-16	49.	4.35	3.41
1/8	5.75	.06	.056	1/8	52.	4.86	3.85
3-16	8.65	.134	.105	3-16	54.9	5.40	4.29
1/4	11.48	.235	.187	1/4	57.65	6.	4.73
5-16	14.36	.375	.295	5-16	60.5	6.60	5.20
3/8	17.28	.54	.424	3/8	53.45	7.27	5.70
7-16	20.19	.735	.575	7-16	66.35	7.90	6.28
1/2	23.1	.960	.75	1/2	69.3	8.64	6.80
9-16	26.	1.21	.95	9-16	72.15	9.28	7.30
5/8	28.85	1.51	1.17	5/8	75.1	10.15	8.
11-16	31.68	1.81	1.42	11-16	77.95	10.95	8.6
3/4	34.57	2.15	1.7	3/4	80.75	11.70	9.24
13-16	36.46	2.54	2.	13-16	83.60	12 60	9.85
7/8	40.39	2.95	2.3	7/8	86.58	13.46	10.55
15-16	43.27	3.37	2.64	15-16	89.45	14.35	11.25
1	46.15	3.84	3.01	2	92.25	15.35	12.

MARKS AND WEIGHTS OF TIN-PLATE.

NAMES.	SIZES.	No. in Box.	WEIGHT OF EACH BOX.			MARKS ON THE BOXES.
	Inches.		cts.	qrs.	lbs.	
Common No. 1.....	13¾x10	225	1	0	0	CI
Common No. 2.....	13¼x 9¼	"	0	3	21	CII
Common No. 3.....	12¾x 9½	"	0	3	16	CIII
Cross No. 1	13¾x10	"	1	1	0	XI
Two Crosses No. 1	" "	"	1	1	21	XXI
Three Crosses No. 1....	" "	"	1	2	14	XXXI
Four Crosses No. 1.....	" "	"	1	3	7	XXXXI
Common Doubles.....	16¾x12½	100	0	3	21	CD
Cross "	" "	"	1	0	14	XD
Two Cross "	" "	"	1	1	7	XXD
Three " "	" "	"	1	2	0	XXXD
Four " "	" "	"	1	2	21	XXXXD
Common Small Doubles	15 x11	200	1	2	0	CSD
Cross " "	" "	"	1	2	21	XSD
Two Cross " "	" "	"	1	3	14	XXSD
Three " " "	" "	"	2	0	7	XXXSD
Four " " "	" "	"	2	1	0	XXXXSD
Waster's Common No. 1	13¾x10	225	1	0	0	WCI
" Cross No. 1...	" "	"	1	1	0	WXI

SHEET IRON.

Black and galvanized sheet iron; weight and measurement per square foot.

Roof wire gauge.	Weight per Sq. foot.	Square foot per ton.	No. of wire gauge.	Weight per Sq. foot.	Square foot per ton.
29	12 oz.	2,987	20	28 oz.	1,327
28	13	2,757	19	30	1,195
27	14	2,560	18	35	1,054
26	15	2,389	17	36	996
25	16	2,240	16	42	853
24	17	1,991	15	46	779
23	19	1,792	14	53	677
22	21	1,629	13	61	588
21	24	1,493	12	70	512

Sheet Iron.—Continued.

COMMON SHEET IRON.

Thickness and weight per square foot of any kind, sheets usually 24 in. wide and 28 in. long.

Thickness wire gauge.	Weight per square foot.		Weight per sheet, 24x28.		Thickness wire gauge.	Weight per square foot.		Weight per sheet, 24x28.	
No.	lbs.	oz.	lbs.	oz.	No.	lbs.	oz.	lbs.	oz.
14	3	12	52	..	24	1	1	14	1
16	3	..	42	..	25	1	..	14	..
18	2	5	32	6	26	0	15	13	2
20	1	9	21	..	27	0	14	12	4
22	1	5	18	6	28	0	12	10	8

WEIGHT OF GALVANIZED SHEET IRON.

No.	Width in inches.	Weight per sheet—lbs.	No.	Width in inches.	Weight per sheet—lbs.
16	24	42	24	28	18
16	30	54	24	30	20
18	24	35	26	24	14
18	28	41	26	28	17
18	30	43	26	30	18
20	24	26	27	24	13
20	28	30	27	28	16
20	30	33	27	30	17
22	24	20	28	24	13
22	28	25	28	28	15
22	30	27	28	30	16
24	24	16			

NET COST AND WEIGHT OF GALVANIZED SHEET IRON.

The following table shows gauges of galvanized sheet iron with weights per square foot; list price per pound; cost per square foot at list, together with cost per pound and per square foot at different discounts. The prices are calculated to three places of decimals, which is sufficiently accurate for all practical purposes.

Gauge Number		14	16	17	18	19
Weight per square foot, oz.		60	48	43	38	33
Light price per pound		.12	.12	.12	.12	.12
Cost per square foot at List		.45	.36	.323	.285	.248
Cost at 5 per ct. Dis.	per lb.	.114	.114	.114	.114	.114
	per sq. ft.	.428	.342	.306	.278	.235
" 7½ " "	per lb.	.111	.111	.111	.111	.111
	per sq. ft.	.416	.333	.298	.264	.229
" 10 " "	per lb.	.108	.108	.108	.108	.108
	per lb. ft.	.405	.324	.290	.257	.223
" 12½ " "	per lb.	.105	.105	.105	.105	.105
	per sq. ft.	.394	.315	.282	.249	.217
" 15 " "	per lb.	.102	.102	.102	.102	.102
	per sq. ft.	.383	.306	.274	.242	.21
" 17½ " "	per lb.	.099	.099	.099	.099	.099
	per sq. ft.	.371	.297	.266	.235	.204
" 20 " "	per lb.	.096	.096	.096	.096	.096
	per sq. ft.	.36	.288	.258	.228	.198
" 22½ " "	per lb.	.093	.093	.093	.093	.093
	per sq. ft.	.349	.279	.25	.221	.192
" 25 " "	per lb.	.09	.09	.09	.09	.09
	per sq. ft.	.338	.27	.242	.214	.186
" 27½ " "	per lb.	.087	.087	.087	.087	.087
	per sq. ft.	.326	.261	.234	.207	.179
" 30 " "	per lb.	.084	.084	.084	.084	.084
	per sq. ft.	.315	.252	.226	.20	.173
" 32½ " "	per lb.	.081	.081	.081	.081	.081
	per sq. ft.	.304	.243	.218	.192	.167
" 33⅓ " "	per lb.	.08	.08	.08	.08	.08
	per sq. ft.	.30	.24	.215	.19	.165
" 35 " "	per lb.	.078	.078	.078	.078	.078
	per sq. ft.	.293	.234	.21	.185	.161
" 37½ " "	per lb.	.075	.075	.075	.075	.075
	per sq. ft.	.281	.225	.202	.178	.155
" 40 " "	per lb.	.72	.072	.072	.072	.072
	per sq. ft.	.27	.216	.194	.171	.149
" 42½ " "	per lb.	.069	.069	.069	.069	.069
	per sq. ft.	.259	.207	.185	.164	.142

Net Cost and Weight of Galvanized Sheet Iron.

(CONTINUED.)

Gauge number		14	16	17	18	19
Weight per square foot, oz.		60	48	43	38	33
List price per pound		.12	.12	.12	.12	.12
Cost per square foot at List		.45	.36	.323	.285	.248
Cost at 45 pr c. Dis.	per lb.	.066	.066	.066	.066	.066
	per sq ft	.248	.198	.177	.157	.136
" 47½ " "	per lb	.063	.063	.063	.063	.063
	per sq. ft	.236	.189	.169	.15	.13
" 50 " "	per lb	.06	.06	.06	.06	.06
	per sq. ft	.225	.18	.161	.143	.124
" 52½ " "	per lb	.057	.057	.057	.057	.057
	per sq. ft	.214	.171	.153	.135	.118
" 55 " "	per lb	.54	.054	.054	.054	.054
	per sq. ft	.203	.162	.145	.128	.111
" 57½ " "	per lb	.051	.051	.051	.051	.051
	per sq. ft	.191	.153	.137	.121	.105
" 60 " "	per lb	.048	.048	.048	.048	.048
	per sq. ft	.18	.144	.129	.114	.099
" 62½ " "	per lb	.045	.045	.045	.045	.045
	per sq. ft	.169	.135	.121	.107	.093
" 65 " "	per lb	.042	.042	.042	.042	.042
	per sq. ft	.157	.126	.113	.100	.087
" 67½ " "	per lb	.039	.039	.039	.039	.039
	per sq. ft	.146	.117	.105	.093	.081
" 70 " "	per lb	.036	.036	.036	.036	.036
	per sq. ft	.135	.108	.097	.085	.074
" 72½ " "	per lb	.033	.033	.033	.033	.033
	per sq. ft	.124	.099	.089	.078	.068
" 75 " "	per lb	.03	.03	.03	.03	.
	per sq. ft	.112	.09	.081	.	.

Gauge Number		20	21	22	23	24
Weight per sq. ft., oz		28	24	21	19	17
List price per pound		.12	.13	.13	.13	.13
Cost per sq. ft. at List		.21	.195	.171	.154	.138
Cost at 5 per ct. Dis.	per lb	.114	.124	.124	.124	.124
	per sq. ft	.20	.185	.162	.147	.131
" 7½ " "	per lb	.111	.12	.12	.12	.12
	per sq. ft	.194	.18	.158	.143	.128
" 10 " "	per lb	.108	.117	.117	.117	.117
	per sq. ft	.189	.176	.154	.139	.124
" 12½ " "	per lb	.105	.114	.114	.114	.114
	per sq. ft	.184	.171	.149	.135	.121

Net Cost and Weight of Galvanized Sheet Iron.

(CONTINUED,)

Gauge number		20	21	22	23	24
Weight per square foot, oz		28	24	21	19	17
List price per pound		.12	.13	.13	.13	.13
Cost per square foot at List		.21	.105	.171	.154	.138
Cost at 15 per c. Dis	per lb.	.102	.111	.111	.111	.111
	per sq. ft.	.179	.166	.145	.131	.117
" 17½ " "	per lb.	.099	.107	.107	.107	.107
	per sq. ft.	.173	.161	.141	.127	.114
" 20 " "	per lb.	.096	.104	.104	.104	.104
	per sq. ft.	.168	.156	.137	.124	.111
" 22½ " "	per lb.	.093	.101	.101	.101	.101
	per sq. ft.	.163	.151	.132	.12	.107
" 25 " "	per lb.	.09	.098	.098	.098	.098
	per sq. ft.	.158	.146	.128	.116	.104
" 27½ " "	per lb.	.087	.094	.094	.094	.094
	per sq. ft.	.152	.141	.124	.112	.10
" 30 " "	per lb.	.084	.091	.091	.091	.091
	per sq. ft.	.147	.137	.119	.108	.097
" 32½ " "	per lb.	.081	.088	.088	.088	.088
	per sq. ft.	.142	.132	.115	.104	.093
" 33⅓ " "	per lb.	.98	.087	.087	.087	.087
	per sq. ft.	.14	.13	.114	.103	.092
" 35 " "	per lb.	.078	.085	.085	.085	.085
	per sq. ft.	.137	.127	.111	.10	.09
" 37½ " "	per lb.	.075	.081	.081	.081	.081
	per sq. ft.	.131	.122	.107	.096	.086
" 40 " "	per lb.	.072	.078	.078	.078	.078
	per sq. ft.	.126	.117	.102	.093	.083
" 42½ " "	per lb.	.069	.075	.075	.075	.075
	per sq. ft.	.121	.112	.098	.089	.079
" 45 " "	per lb.	.066	.072	.072	.072	.072
	per sq. ft.	.116	.107	.094	.085	.076
" 47½ " "	per lb.	.063	.068	.068	.068	.068
	per sq. ft.	.11	.102	.09	.081	.073
" 50 " "	per lb.	.06	.065	.065	.065	.065
	per sq. ft.	.105	.098	.085	.077	.069
" 52½ " "	per lb.	.057	.062	.062	.062	.062
	per sq. ft.	.10	.093	.081	.073	.066
" 55 " "	per lb.	.054	.059	.059	.059	.059
	per sq. ft.	.095	.088	.077	.069	.062
" 57½ " "	per lb.	.051	.055	.055	.055	.055
	per sq. ft.	.089	.083	.073	.066	.059
" 60 " "	per lb.	.048	.052	.052	.052	.052
	per sq. ft.	.084	.078	.068	.062	.055

Net Cost and Weight of Galvanized Sheet Iron.

(CONTINUED.)

Gauge number		20	21	22	23	24
Weight per square foot, oz.		28	24	21	19	17
List price per pound		.12	.13	.13	.13	.13
Cost per square foot at List		.21	.105	.171	.154	.138
Cost at 62½% Dis.	per lb.	.045	.049	.049	.049	.049
	per sq. ft.	.079	.073	.064	.058	.052
" 65 " "	per lb.	.042	.045	.045	.045	.045
	per sq. ft.	.073	.068	.060	.054	.048
" 67½ " "	per lb.	.039	.042	.042	.042	.042
	per sq. ft.	.068	.063	.056	.050	.045
" 70 " "	per lb.	.036	.039	.039	.039	.039
	per sq. ft.	.063	.058	.051	.046	.041
" 72½ " "	per lb.	.033	.036	.036	.036	.036
	per sq. ft.	.058	.054	.047	.042	.038
" 75 " "	per lb.	.03	.032	.032	.032	.032
	per sq. ft.	.052	.049	.042	.038	.034

Gauge Number		25	26	27	28	29
Weight per square foot, oz.		16	15	14	13	12
List price per pound		.14	.14	.15	.16	.18
Cost per square foot at List		.14	.131	.131	.13	.135
Cost at 5 per ct. Dis.	per lb.	.133	.133	.143	.152	.171
	per sq. ft.	.133	.125	.125	.124	.128
" 7½ " "	per lb.	.13	.13	.139	.148	.167
	per sq. ft.	13	.121	.121	.120	.125
" 10 " "	per lb.	.126	.126	.135	.144	.162
	per sq. ft.	.126	.118	.118	.117	.122
" 12½ " "	per lb.	.123	.123	.131	.14	.158
	per sq. ft.	.123	.115	.115	.114	.118
" 15 " "	per lb.	.119	.119	.128	.136	.153
	per sq. ft.	.119	.112	.112	.111	.115
" 17½ " "	per lb.	.116	.116	.124	.132	.149
	per sq. ft.	.116	.108	.108	.107	.111
" 20 " "	per lb.	.112	.112	.12	.128	.144
	per sq. ft.	.112	.105	.105	.104	.108
" 22½ " "	per lb.	.109	.109	.116	.124	.14
	per sq. ft.	.109	.102	.102	.101	.105
" 25 " "	per lb.	.105	.105	.113	.12	.135
	per sq. ft.	.105	.098	.098	.098	.101
" 27½ " "	per lb.	.102	.102	.109	.116	.138
	per sq. ft.	.102	.095	.095	.094	.096
" 30 " "	per lb.	.098	.098	.105	.112	.125
	per sq. ft.	.098	.092	.092	.094	.092

Net Cost and Weight of Galvanized Sheet Iron.

(CONTINUED.)

Gauge Number		25	26	27	28	29
Weight per square foot, oz		16	15	14	13	12
List price per pound		.14	.14	.15	.16	.18
Cost per square foot at List		.14	.131	.131	.13	.135
Cost at 32½ p.c. Dis	per lb	.095	.095	.101	.108	.121
	per sq. ft	.095	.089	.089	.088	.09
" 33⅓ " "	per lb	.093	.093	.10	.107	.12
	per sq. ft	.093	.088	.088	.087	.097
" 35 " "	per lb	.091	.091	.098	.104	.118
	per sq. ft	.091	.085	.085	.085	.083
" 37½ " "	per lb	.088	.088	.094	.10	.114
	per sq. ft	.088	.082	.082	.081	.088
" 40 " "	per lb	.084	.084	.09	.096	.101
	per sq. ft	.084	.079	.079	.078	.084
" 42½ " "	per lb	.081	.081	.086	.092	.108
	per sq. ft	.081	.075	.075	.075	.079
" 45 " "	per lb	.077	.077	.083	.088	.094
	per sq. ft	.077	.072	.072	.072	.075
" 47½ " "	per lb	.074	.074	.079	.084	.091
	per sq. ft	.074	.069	.069	.068	.07
" 50 " "	per lb	.07	.07	.075	.08	.098
	per sq. ft	.07	.066	.066	.065	.066
" 52½ " "	per lb	.067	.067	.071	.076	.084
	per sq, ft	.067	.062	.062	.062	.061
" 55 " "	per lb	.063	.063	.068	.072	.081
	per sq. ft	.063	.059	.059	.059	.087
" 57½ " "	per lb	.06	.06	.064	.068	.077
	per sq. ft	.06	.056	.056	.055	.056
" 60 " "	per lb	.056	.056	.06	.064	.072
	per sq. ft	.056	.052	.052	.052	.054
" 62½ " "	per lb	.052	.052	.056	.060	.067
	per sq. ft	.052	.049	.049	.049	.051
" 65 " "	per lb	.049	.049	.052	.056	.063
	per sq. ft	.049	.046	.046	.045	.047
" 67½ " "	per lb	.045	.045	.049	.052	.058
	per sq. ft	.045	.043	.043	.042	.044
" 70 " "	per lb	.042	.042	.045	.048	.054
	per sq. ft	.042	.039	.039	.039	.040
" 72½ " "	per lb	.038	.038	.041	.044	.049
	per sq. ft	.038	.036	.036	.036	.037
" 75 " "	per lb	.035	.035	.037	.040	.045
	per sq. ft	.035	.033	.033	.032	.034

REGISTERS AND VENTILATORS, VERTICAL WHEEL.

Sizes as given on List	Opening to admit Body of Register.	Extreme Dimensions of Register Face.	Depth of the Register. Clos'd	Depth of the Register. Open	Opening to admit Iron Border.
4¼ x 6½ in.	4⅝ x 6⅝	5¾ x 7¾	1⅝	2	. . . . .
4 x 8 in.	4⅜ x 8¼	5½ x 9½	1⅞	2½	. . . . .
4 x10 in.	4⅜ x10¼	5¾ x11¾	1⅞	2½	. . . . .
4 x15 in.	4⅜ x15	5¾ x16⅞	1⅞	2½	. . . . .
4 x18 in.	4⅜ x1	5⅝ x19¼	1⅞	2½	. . . . .
6 x 8 in.	6½ x 8⅜	7⅞ x 9¾	1⅞	2½	10⅜ x12¼
6 x 9 in.	6½ x 9½	8 x10¾	1⅞	2½	10½ x13¼
6 x10 in.	6⅝ x10½	8 x12	1⅞	2½	10⅜ x14⅜
6 x14 in.	6½ x14¼	8⅛ x15⅝	1⅞	2½	11⅛ x18⅝
6 x16 in.	6½ x16	8⅛ x17¾	1⅞	2½	11⅛ x20¾
6 x18 in.	6½ x18⅛	8⅛ x20	1⅞	2½	11⅛ x22¾
6 x24 in.	6½ x24⅛	8 x26	1⅞	2½	11⅛ x28⅞
7 x 7 in.	7⅜ x 7⅜	8⅝ x 8⅝	2	2¾	11⅛ x11⅛
7 x10 in.	7⅜ x10½	8¾ x11¾	2	2¾	11⅛ x14⅛
8 x 8 in.	8¼ x 8¼	9⅞ x 9⅞	2⅛	3	12⅝ x12⅝
8 x10 in.	8⅜ x10¾	9⅝ x11⅝	2⅛	3	12¼ x14⅜
8 x12 in.	8¼ x11⅞	9¾ x13⅝	2⅛	3	12¾ x16⅝
8 x15 in.	8⅜ x15⅜	9¾ x16⅝	2⅛	3	12¾ x19⅝
8 x18 in.	8¾ x18¼	10 x19⅞	2⅛	3	12¾ x22⅞
9 x 9 in.	9¼ x 9¼	10¾ x10¾	2¼	3¼	13⅝ x13¾
9 x12 in.	9¼ x12	10¾ x13¾	2¼	3¼	13⅝ x16⅝
9 x14 in.	9¼ x14⅛	11 x 6⅛	2¼	3¼	13⅞ x19⅛
10 x10 in.	10⅛ x10¼	12 x12	2½	3¾	14¾ x14¾
10 x12 in.	10⅛ x12½	11¾ x14	2½	3¾	15⅛ x17⅜
10 x14 in.	10⅛ x14¼	12¼ x16¼	2½	3¾	15⅜ x19⅜
10 x16 in.	10⅛ x16⅛	12 x18	2½	3¾	15 x21¼
10½ x16½ in.	10⅝ x16½	12⅝ x18½	2½	3¾	15½ x21⅝
12 x12 in.	12 x12	14 x14	2⅝	4¼	16¾ x16¾
12 x15 in.	12 x15	13⅝ x16⅞	2⅝	4¼	16⅜ x19⅝
12 x17 in.	12 x17¼	14 x19	2⅝	4¼	17½ x22¼
12 x19 in.	12⅛ x19⅛	14¼ x21⅛	2⅞	4½	17⅜ x24
14 x14 in.	14⅜ x14⅜	16½ x16½	2¾	4	19½ x19¾
14 x18 in.	14⅜ x18¼	16½ x20½	2¾	4	19¾ x23½
14 x22 in.	14⅜ x21⅞	16½ x24	2¾	4	19⅞ x27¼
16 x16 in.	16⅜ x16⅜	18⅜ x18⅜	2⅞	4½	21⅜ x21⅝
16 x20 in.	15⅞ x20⅛	17½ x21¾	2⅞	4½	20¾ x25⅞
16 x24 in.	16⅜ x24¼	18⅜ x26¾	2⅞	4½	22 x30½
20 x20 in.	21¼ x21¼	22¾ x22¾	3½	5½	27⅛ x27⅛
20 x26 in.	20⅛ x26	22¾ x28¾	3⅝	5⅝	27½ x33¼
21 x29 in.	21 x29	23½ x31¼	3¾	5¾	28¼ x36⅛
30 x30 in.	30 x30	32⅝ x32⅝	3⅝	6	37¾ x37¾

NO. POUNDS OF ROUND AND SQUARE BAR IRON PER FOOT.

Diam. of Side.	Square Bars.	Round Bars.	Breadth or Diam. in Inches.	Square Bars.	Round Bars.	Breadth or Diam. in Inches.	Square Bars.	Round Bars.
¼	.209	.164	1	3.34	2.62	2⅞	27.61	21.68
5-16	.326	.256	1⅛	4.22	3.32	3	30.07	23.60
⅜	.470	.369	1¼	5.25	4.09	3¼	35.28	27.70
7-16	.640	.502	1⅜	6.35	4.96	3½	40.91	32.23
½	.835	.656	1½	7.51	5.90	4¾	46.97	36.89
9-16	1.057	.831	1⅝	8.82	6.92	4	53.44	41.97
⅝	1.305	1.025	1¾	10.29	8.03	4¼	60.32	47.38
11-16	1.579	1.241	1⅞	11.74	9.22	4½	67.63	53.12
¾	1.879	1.476	2	13.36	10.49	4¾	75.35	59.18
13-16	2.205	1.732	2⅛	15.08	11.84	5	83.51	65.58
⅞	2.556	2.011	2¼	16.91	13.27	5¼	92.46	72.39
15-16	2.936	2.306	2⅜	18.84	14.79	5½	101.03	79.35
			2½	20.87	16.39	5¾	114.43	86.73
			2⅝	23.11	18.07	6	120.24	94.43
			2¾	25.26	19.84			

INTERNAL AREAS OF WROUGHT IRON PIPE.

Size of Pipe.	Internal Area.	Length per foot of Surface.	Gallons per foot in Length.
½ in.	0.3648 in.	4.502 ft.	0.0102 gal.
¾ "	0.5333 "	3.637 "	0.0230 "
1 "	0.8627 "	2.903 "	0.0408 "
1¼ "	1.496 "	2.301 "	0.0638 "
1½ "	2.038 "	2.01 "	0.0918 "
2 "	3.355 "	1.611 "	0.1632 "
2½ "	4.783 "	1.328 "	0.2550 "
3 "	7.388 "	1.091 "	0.3673 "
3½ "	9.887 "	0.955 "	0.4998 "
4 "	12.730 "	0.849 "	0.6528 "
4½ "	15.939 "	0.765 "	0.8263 "
5 "	19.990 "	0.629 "	1.020 "
6 "	28.889 "	0.577 "	1.469 "
7 "	38.737 "	0.535 "	1.999 "
8 "	50.039 "	0.444 "	2.611 "

WILSON'S TABLE OF DIMENSIONS OF CHIMNEYS.

Height of Chimney in feet.	Lbs. of coal per hour per 1 foot of area at top of Chimney.	Height in inches of column of water balanced by draught pressure.	Horse power of each sq. ft. of Chimney. Assuming 7 lbs. of coal per horse power.	Area of top of Chimney in ft. per horse power for 1 or 2 boilers.	Area of top of Chimney in ft. per horse power where several boilers are working together.	Area of flue in feet per horse power.
30	78.24	.218	7.3	.146	.091	.182
40	90.35	.296	8.4	.126	.077	.155
50	101.01	.364	9.4	.113	.070	.140
60	110.65	.437	10.3	.103	.064	.129
70	119.52	.5	11.2	.095	.059	.119
80	127.77	.58	11.9	.089	.055	.111
90	135.52	.656	12.6	.084	.052	.105
100	142.85	.729	13.3	.08	.05	.01
125	159.71	.911	14.9	.071	.054	.089
150	174.96	1.09	16.3	.065	.04	.082
175	188.98	1.26	17.6	.060	.038	.075
200	202.03	1.45	18.8	.056	.035	.07
225	214.28	1.64	20	.053	.033	.066
250	225.87	1.82	21	.05	.031	.063
275	236.90	1.99	22	.048	.03	.06
300	247.43	2.18	23	.046	.028	.057

SPUN BRASS KETTLES--WEIGHT AND CAPACITY OF.

Diameter Inches.	Weight. Pounds.	Capacity. Gallons.	Diameter. Inches.	Weight. Pounds.	Capacity Gallons.
7	1	½	18	10½	10
8	1½	1	19	12½	12
9	2½	1½	20	16½	14
10	3	2	21	18	17
11	3½	2½	22	20	18
12	4	3	23	23	23
13	5	4	24	27½	25
14	5¾	4½	25	29	30
15	6½	5	26	32	32
16	7½	6	27	37	37
17	9	8	28	40	42

COST OF TIN ROOFING PER SQUARE AND SQUARE FOOT.

FLAT SEAM ROOFING—COST WITH 20x28 TIN.

Price of Tin per box.	Cost per square of flat roof 20x28 Tin.	Cost per sq. foot.	Price of Tin per box.	Cost per square of flat roof 20x28 Tin.	Cost per sq. foot.
$8.00	$ 2.01	.0201	$16.00	$4.01	.0401
8.50	2.13	.0213	16.50	4.13	.0413
9.00	2.26	.0226	17.00	4.26	.0426
9.50	2.38	.0238	17.50	4.38	.0438
10.00	2.51	.0251	18.00	4.51	.0451
10.50	2.63	.0263	18.50	4.63	.0463
11.00	2.76	.0276	19.00	4.76	.0476
11.50	2.88	.0288	19.50	4.88	.0488
12 00	3.00	.0300	20.00	5.01	.0501
12.50	3.13	.0313	20.50	5.14	.0513
13.00	3.25	.0325	21.00	5.26	.0526
13.50	3.38	.0338	21.50	5.38	.0538
14 00	3.50	.0350	22.00	5.51	.0551
14.50	3.63	.0363	22.50	5.63	.0563
15.00	3.75	.0375	23.00	5.76	.0576
15.50	3.88	.0388			

STANDING SEAM ROOFING—COST WITH 20x28 TIN.

Price of Tin per box.	Cost per square of standing seam roof with 20x28 Tin.	Cost per sq. foot.	Price of Tin per box.	Cost per square of standing seam roof with 20x28 Tin.	Cost per sq. foot.
$8.00	$ 2.15	.0215	$16.50	$4.42	.0442
8.50	2.28	.0228	17.00	4.56	.0456
9.00	2.41	.0241	17.50	4.69	.0469
9.50	2.55	.0255	18.00	4.82	.0482
10.00	2.68	.0268	18.50	4.96	.0496
10.50	2.82	.0282	19.00	5.09	.0509
11.00	2.95	.0295	19.50	5.23	.0523
11.50	3.09	.0309	20.00	5.36	.0536
12.00	3.21	.0321	20.50	5.49	.0549
12.50	3.35	.0335	21.00	5.63	.0563
13.00	3.48	.0348	21.50	5.76	.0576
13.50	3.62	.0362	22.00	5.90	.0590
14.00	3.75	.0375	22.50	6.03	.0603
14.50	3.89	.0389	23.00	6.17	.0617
15.00	4.02	.0402	23.50	6.30	.0630
15.50	4.15	.0415	24.00	6.43	.0643
16.00	4.29	.0429			

Cost of Tin Roofing per Square and Square Foot.

(CONTINUED.)

FLAT SEAM ROOFING—COST WITH 14x20 TIN.

Price of Tin per box.	Cost per square of flat roof 14x20 Tin.	Cost per sq. foot.	Price of Tin per box.	Cost per square of flat roof 14x20 Tin.	Cost per sq. foot.
$4.25	$ 2.21	.0221	$ 8.25	$4.29	.0429
4.50	2.34	.0234	8.50	4.42	.0442
4.75	2.47	.0247	8.75	4.55	.0455
5.00	2.60	.0260	9.00	4.68	.0468
5.25	2.73	.0273	9.25	4.81	.0481
5.50	2.86	.0286	9.50	4.94	.0494
5.75	2.99	.0299	9.75	5.07	.0507
6.00	3.12	.0312	10.00	5.20	.0520
6.25	3.25	.0325	10.25	5.33	.0533
6.50	3.38	.0338	10.50	5.46	.0546
6.75	3.51	.0351	10.75	5.59	.0559
7.00	3.64	.0364	11.00	5.72	.0572
7.25	3.77	.0377	11.25	5.85	.0585
7.50	3.90	.0390	11.50	5.98	.0598
7.75	4.03	.0403	11.75	6.11	.0611
8.00	4.16	.0416	12.00	6.24	.0624

STANDING SEAM ROOFING—COST WITH 14x20 TIN.

Price of Tin per box.	Cost per square of stand'g seam roof with 14x20 Tin.	Cost per sq. foot.	Price of Tin per box.	Cost per square of stand'g seam roof with 14x20 Tin.	Cost per sq. foot.
$4.25	$ 2.37	.0237	$ 7.25	$4.03	.0403
4.50	2.51	.0251	7.50	4.17	.0417
4.75	2.65	.0265	7.75	4.31	.0431
5.00	2.79	.0279	8.00	4.45	.0445
5.25	2.93	.0293	8.25	4.59	.0459
5 50	3.06	.0306	8.50	4.73	.0473
5.75	3.20	.0320	8.75	4.87	.0487
6.00	3.34	.0334	9.00	5.01	.0501
6.25	3.48	.0348	9.25	5.15	.0515
6.50	3.62	.0362	9.50	5.29	.0529
6.75	3.76	.0376	9.75	5.43	.0543
7.00	3.90	.0390	10.00	5.57	.0557

SLATE TABLE.

Size of Slate.	Nails to Square.	Exposed When Laid.	Number in Square.
14x24	1 lb 3d	10½ in.	98
13x24	1½ "	10½ "	106
12x24	1½ "	10½ "	115
12x22	1½ "	9½ "	127
11x22	1½ "	9½ "	138
12x20	1¾ "	8½ "	141
11x20	1¾ "	8½ "	154
10x20	1¾ "	8½ "	170
10x18	1 "	7½ "	192
9x18	2½ "	7½ "	214
10x16	2¾ "	6½ "	222
9x16	3 "	6½ "	247
8x16	3 "	6½ "	277
10x14	3 "	5½ "	262
8x14	3¾ "	5½ "	327
7x14	4 "	5½ "	374
8x12	4¼ "	4½ "	400
7x12	4¾ "	4½ "	457
6x12	5½ "	4½ "	533

WEIGHT OF LEAD PIPE AND TIN-LINED LEAD PIPE.

STANDARD WEIGHT PER FOOT.

Calibre	Brooklyn. AAA		Ex. Strong. AA		Strong. A		Medium B		Light. C		Ex. Light. D		Fountain. E	
	Lb.	Oz.	Lb.	Oz.	Lb.	Oz	Lb.	Oz.	Lb.	Oz.	Lb.	Oz.	Lb.	Oz.
⅜	1	8	1	5	1	2	1	0	0	13	0	10	0	8
½	3	0	2	0	1	12	1	4	1	0	0	13	0	11
⅝	3	8	2	12	2	8	2	0	1	12	1	8	1	0
¾	4	8	3	8	3	0	2	4	2	0	1	12	1	4
1	6	0	4	12	4	0	3	4	2	8	2	0	1	8
1¼	6	12	5	12	4	12	3	12	3	0	2	8	2	0
1½	9	0	8	0	6	4	5	0	4	4	3	8	3	4
2	10	12	9	0	7	0	6	0	5	4	4	0	..	..

WIRE GAUGE STANDARDS.

Number of Wire gauge.	American or Brown & Sharpe	Birmingham, or Stubbs's.	Washburn & Moen M'f'g. Co., Worcester Mass.	Trenton Iron Co., Trenton N. J.	G. W. Prentiss, Holyoke, Mass.	Old English from Brass M'f'rs'. List.	Number of wire gauge.
000000	.....	.....	.46	.....	.....	.....	000000
00000	.....	.....	.43	.45	.....	.....	00000
0000	.46	.454	.393	.4	.....	.....	0000
000	.40964	.425	.362	.36	.3586	.....	000
00	.3648	.38	.331	.33	.3282	.....	00
0	.32495	.34	.307	.305	.2994	.....	0
1	.2893	.3	.283	.285	.2777	.....	1
2	.25763	.284	.263	.265	.2591	.....	2
3	.22942	.259	.244	.245	.2401	.....	3
4	.20431	.238	.225	.225	.223	.....	4
5	.18194	.22	.207	.205	.2047	.....	5
6	.16202	.203	.192	.19	.1885	.....	6
7	.14428	.18	.177	.175	.1758	.....	7
8	.12849	.165	.162	.16	.1605	.....	8
9	.11443	.148	.148	.145	.1471	.....	9
10	.10189	.134	.135	.13	.1351	.....	10
11	.090742	.12	.12	.1175	.1205	.....	11
12	.080808	.109	.105	.105	.1965	.....	12
13	.071961	.095	.092	.0925	.0928	.....	13
14	.064084	.083	.08	.08	.0816	.083	14
15	.057068	.072	.072	.07	.0726	.072	15
16	.05082	.065	.063	.061	.0627	.065	16
17	.045257	.058	.054	.0525	.0546	.058	17
18	.040303	.049	.047	.045	.0478	.049	18
19	.03589	.042	.041	.04	.0411	.04	19
20	.031961	.035	.035	.035	.0351	.035	20
21	.028462	.032	.032	.031	.0321	.0315	21
22	.025347	.028	.028	.028	.029	.0295	22
23	.022571	.025	.025	.025	.0261	.027	23
24	.0201	.022	.023	.0225	.0231	.025	24
25	.0179	.02	.02	.02	.0212	.023	25
26	.01594	.018	.018	.018	.0194	.0205	26
27	.014195	.016	.017	.017	.0182	.01875	27
28	.012641	.014	.016	.016	.017	.0165	28
29	.011257	.013	.015	.015	.0163	.0155	29
30	.010025	.012	.014	.014	.0156	.01375	30
31	.008928	.01	.0135	.013	.0146	.01225	31
32	.00795	.009	.013	.012	.0136	.01125	32
33	.00708	.008	.011	.011	.013	.01025	33
34	.006304	.007	.01	.01	.0118	.0095	34
35	.005614	.005	.009	.0095	.0109	.009	35
36	.005	.004	.009	.009	.01	.0075	36
37	.004453	.....	.008	.0085	.0095	.0065	37
38	.003965	.....	.008	.008	.009	.00575	38
39	.003531	.....	.007	.0075	.0083	.005	39
40	.003144	.....	.007	.007	.0078	.0045	40

WEIGHT OF ONE FOOT OF BAR STEEL.

ROUND.		SQUARE.		OCTAGON.	
Diam. In.	Pounds.	Side In.	Pounds.	Diam. In.	Pounds.
¼	.166	¼	.213	½	.84
⅜	.375	⅜	.479	⅝	1.23
½	.667	½	.855	¾	1.75
⅝	1.04	⅝	1.33	⅞	2.25
¾	1.50	¾	1.91	1	2.75
⅞	2 05	⅞	2.61	1⅛	3.66
1	2.67	1	3.40	1¼	4.55
1⅛	3.38	1⅛	4.34	1⅜	5.50
1¼	4.17	1¼	5.32	1½	6.45
1⅜	5.05	1⅜	6.44	1⅝	7.75
1½	6.00	1½	7.67	1¾	9.20
1⅝	7.05	1⅝	9.00	1⅞	10.04
1¾	8.17	1¾	10.44	2	11.60
1⅞	9.38	1⅞	11.98	2⅛	13.14
2	10.68	2	13.63	2¼	14.75
2⅛	12.04	2⅛	15.35	2⅜	16.40
2¼	13.51	2¼	17.20	2½	17.85
2⅜	15.05	2⅜	19.17	2⅝	19.50
2½	16.68	2½	21.20	2¾	21.25
2⅝	18.43	2⅝	23.30	2⅞	22.69
2¾	20.19	2¾	25.70	3	25.00
2⅞	22.00	2⅞	27.74		
3	24.03	3	30.60		
3¼	28.20	3¼	35.90		

USEFUL TABLES FOR TIN-PLATE WORKERS.

List of abbreviations used: W. No.—Wire number. Pat. No.—Pattern number. No.—Number. B. W. G.—Birmingham wire gauge.

Note on table No. 1: Length and sizes of B. G. wire.—This little table is very useful for finding how much wire you will require to make given number of articles, and will be found a very useful table for reference.

Note on table No. 2: Oil Bottles.—These sizes after being made with cone-shaped top and neck will hold rather more than quantities given, so as to hold the quantity after rebottoming and repairs.

Water Pots sec. 3.—All these sizes are so arranged as to cut best out of the different sizes of tinplates.

Note on table No. 4, Dripping Tins.—They are turned up at an angle of 90 degrees to sizes given in table.

Saucepans and Paint Kettles, see 5 and 6.—These sizes are arranged so they will hold quantity stated after rebottoming.

Note on tables 7: Baking Tins.—You can see you will get six sides of a No. 1 from a single sheet, six sides of a No. 2 from a small double sheet without any waste. Numbers 9 and 10 are self-explanatory.

Funnels No. 8.—These are so arranged as to cut as nicely as possible, and can be wired with or without rim as desired.

Note on table 10: Oval Breakfast Bottles.—This is an article made oval with lock seam, top being funnel-shape with round neck. The sizes given will be found to cut as nicely as can be arranged. The handle is both riveted and soldered on and top and bottom clasped on, or bottom can be panned down and turned up and top panned on as desired. Some people make them one way and others the other.

Fish Kettles and Round Boilers, See 11 and 12.—The bodies of round and oval boilers differ very much in depth. An oval boiler is mostly known as a fish kettle and a round boiler as a pea boiler.

1

YARDS OF WIRE PER BUNDLE.

Wires all weigh 63 pounds to the bundle.

Wire Gauge.	Yds. Per Bundle.	Wire Gauge.	Yds. Per Bundle.	Wire Gauge.	Yds. Per Bundle.
0.....	71	7.....	239	14.....	1,142
1.....	91	8.....	286	15.....	1,468
2.....	105	9.....	342	16.....	1,954
3.....	121	10.....	420	17.....	2,540
4.....	143	11.....	529	18.....	3,150
5.....	170	12.....	700	19.....	4,085
6.....	203	13.....	893	20.....	4,912

2

OIL BOTTLES.

Capacity.	Size.		Capacity.	Size.	
Half pint.....	7⅞ in.	3½ in.	Half gallon....	18½ in.	5½ in.
One pint.....	10 "	4⅝ "	One gallon.....	22 "	7½ "
One quart.....	14 "	5 "	Two gallons....	28 "	10 "

3

WATER POTS.

No.	Capacity.	Size.
000	About 1 pint...	
00	About 2 pints..	
0	About 4 pints..	
1	About 6 pints..	17 in. 6¼ in.
2	About 8 pints..	20 " 7 "
3	About 1½ gals..	24 in. 9 in
4	About 2 gals..	28 " 10 "
5	About 3 gals..	30 " 11 "
6	About 4 gals..	34 " 11½ "
7	About 5 gals..	40 " 14 "

4

DRIPPING TINS.

W. No.	Finished Size.	Size.		Remarks.
13	1¾ in.	14 in.	10 in.	Turn up an angle of 90°.
12	2 "	15 "	10 "	" " " "
11	2¼ "	17 "	12½ "	" " " "
9	2½ "	20 "	14 "	" " " "

5

SAUCEPANS.

W. No.	Capacity.	Size.	
13	1 pint...	13 in.	3⅜ in.
12	2 pints..	14 "	5 "
11	3 pints..	18½ "	5½ "
10	2 quarts...	20 in.	7 in.
	3 quarts...	22 "	7½ "
	4 quarts...	25 "	8½ "

6

PAINT KETTLES.

W. No.	Capacity.	Size.	
12	1 pt., 3 lbs...	14 in.	5 in
11	2 " 4 " ...	17⅛ "	5 "
10	3 " 5 " ...	20 "	5 "
9	2 qts., 6 lbs...	22⅛ in.	5¼ in
	3 " 7 " ..	25 "	6¼ "
	4 " 8 " ..		

7

BAKING TINS.

No.	W. No.	Side. Top.	Side. Bottom.	End. Top.	End. Bottom.	Deep.	Remarks.
1	13	7 in.	6 in.	5 in.	4 in.	3⅓ in.	6 sides of a No. 1 from an S sheet.
2	12	7½ "	6½ "	5½ "	4½ "	3⅔ "	6 sides of a No. 2 from an SD sheet.
3	10	8½ "	7½ "	6¼ "	5¼ "	4¼ "	6 sides of a No. 3 from a D sheet.

8

FUNNELS.

Top.	Bottom.	W. No.	Top.	Bottom.	W. No.	Top.	Bottom,	W. No.
2 in.	⅜ in.	15	4 in.	1 in.	13	8 in.	1½ in.	10
2½ "	½ "	15	5 "	1¼ "	13	10 "	1½ "	9
3 "	⅝ "	14	6 "	1½ "	12			

9.

TINPLATES.

S single .....14 in 0 in.	and 20 in. sq. sheets.
S D small double..15 " 11 "	Tinned iron sheets, 26 B. W. G.
D double.....17 " 12½ "	72 in., 24 in.
Twenties .....20 " 14 "	Tinned iron sheets, 24 B. W. G.
D D double doubles25 " 17 "	72 in., 30 in.
Twenty-eights ....28 " 20 "	Tinned iron sheets, 22 B. W. G.
There are 17 in., 18 in., 19 in.	72 in., 22 in.

10

OVAL BREAKFAST BOTTLES.

Capacity.	Size.	Capacity.	Size.
1 pint.....10 in.	4½ in.	2 pints .....13 in.	5 in.
1½ pints.....12 "	4⅝ "	3 pints .....13⅜ "	6 "

11

FISH KETTLES.

W. No.	No.	Size.		W. No.	No.	Size.	
7	1	40 in.	7 in.	5	3	50 in.	½ in.
6	2	44 "	7½ "	¼ in. rod	4	56 "	10 "

12

ROUND BOILERS.

W. No.	No.	Size.		W. No.	No.	Size.	
8	1	28 in.	10 in.	6	3	33½ in.	10 in.
7	2	31 "	10 "	5	4	36 "	11 "

TIN-PLATE.

MARKS, WEIGHTS AND NUMBERS.

TIN PLATES.

Mark.	Size.	Sheets in box.	Nominal net weight per box. Lb.
IC	10 x14	225	108
IX	10 x14	225	135
IXX	10 x14	225	156
IXXX	10 x14	225	178
IXXXX	10 x14	225	198
IC	14 x20	112	108
IX	14 x20	112	135
IXX	14 x20	112	156
IXXX	14 x20	112	178
IXXXX	14 x20	112	198
IC	20 x28	112	216
IX	20 x28	112	270
IXX	20 x28	112	320
IXXX	20 x28	112	360
IXXXX	20 x28	112	400
DC	12½x17	100	94
DX	12½x17	100	122
DXX	12½x17	100	143
DXXX	12½x17	100	164
DXXXX	12½x17	100	185
DC	17 x25	100	188
DX	17 x25	100	244
DXX	17 x25	100	286
DXXX	17 x25	100	328
DXXXX	17 x25	100	370
IC	11 x11	225	97
IX	11 x11	225	121
IXX	11 x11	225	139
IC	12 x12	225	112
IX	12 x12	225	140
IXX	12 x12	225	161
IC	13 x13	225	135
IX	13 x13	225	169
IXX	13 x13	225	194
IC	14 x14	225	156
IX	14 x14	225	196
IXX	14 x14	225	225
IC	15 x15	225	180
IX	15 x15	225	225
IXX	15 x15	225	259
IC	16 x16	225	204
IX	16 x16	225	256
IXX	16 x16	225	294
IC	17 x17	112	115
IX	17 x17	112	144
IXX	17 x17	112	166
IC	18 x18	112	130
IX	18 x18	112	162
IXX	18 x18	112	186
IC	19 x19	112	144
IX	19 x19	112	180
IXX	19 x19	112	207
IC	20 x20	112	160
IX	20 x20	112	200
IXX	20 x20	112	230
IC	21 x21	112	176
IX	21 x21	112	220
IXX	21 x21	112	253
IC	22 x22	112	194
IX	22 x22	112	242
IXX	22 x22	112	278
IC	24 x24	112	231
IX	24 x24	112	288
IXX	24 x24	112	331
IXXX	24 x24	112	374
IXXXX	24 x24	112	417
IC	10 x20	225	160

Tin Plate—Continued.

MARKS, WEIGHTS AND NUMBERS.

TIN PLATE.

Mark.	Size.		Sheets in box.	Nominal net weight per box. Lb.
IX	10	x20	225	200
IXX	10	x20	225	230
IC	11	x22	225	194
IX	11	x22	225	242
IXX	11	x22	225	278
IC	12	x24	112	112
IX	12	x24	112	140
IXX	12	x24	112	161
IC	13	x26	112	135
IX	13	x26	112	169
IXX	13	x26	112	194
IC	14	x28	112	156
IX	14	x28	112	196
IXX	14	x28	112	225
IC	14	x31	112	174
IX	14	x31	112	217
IXX	14	x31	112	250
IC	14	x22	112	123
IX	14	x22	112	154
IC	14	x22	112	126
IX	14	x22	112	157
IXX	20	x72	46	7¼
IXXX	20	x72	37	9½
IXX	30	x72	30	11¾
IXXX	30	x72	27	12¾
IXXXX	30	x72	25	14
IXXX	36	x72	35	15¼
IXXXX	36	x72	20	17½
IXXXX	38	x84	16	19½
IXXXX	40	x84	14	25

TERNE PLATES.

IC	14	x20	112	108
IX	14	x20	112	135
IC	20	x28	112	216

TAGGERS TIN AND TAGGERS IRON.

Size.	Wire Gauge.	Sheets.	
10x14	No. 38	450	112 lb.
10x14	No. 36	360	112 "
10x14	No. 34	300	112 "
14x20	No. 38	225	112 "
14x20	No. 36	180	112 "
14x20	No. 34	150	112 "
20x28	No. 30	112	224 "
20x36	No. 30	87	224 "
20x28	No. 32	112	180 "
20x36	No. 32	87	180 "
20x40	No. 37	78	180 "

TABLE OF WEIGHTS PER FOOT OF GALVANIZED SHEET IRON PIPE.

Weight per foot in pounds and decimal parts of galvanized sheet iron pipe from 5 to 24 inches in diameter and from No. 14 to No. 20 Birmingham wire gauge. One inch is allowed for seam in grooving or lap in riveting.

Diameter of Pipe.	Number Wire Gauge.														
	29	28	27	26	25	24	23	22	21	20	19	18	17	16	14
5	991	1131	1218	1304	1392	1479	1653	1827	2088	2436	2871	3306	3737	4176	5220
6	1177	1344	1446	1549	1653	1756	1961	2169	2479	2892	3409	4125	4438	4959	6198
7	1364	1555	1675	1795	1915	2034	2274	2513	2872	3351	3949	4548	5141	5745	7181
8	1551	1768	1904	2041	2177	2313	2585	2857	3265	3809	4490	5170	5845	6531	8163
9	1742	1981	2134	2286	2439	2591	2896	3201	3658	4268	5030	5792	6548	7317	9146
10	1923	2193	2362	2531	2700	2868	3206	3543	4050	4725	5568	6412	7249	8100	10125
11	2110	2406	2591	2776	2962	3147	3517	3887	4430	5183	6109	7034	7952	8886	11107
12	2296	2618	2820	3021	3223	3424	3827	4230	4834	5640	6641	7654	8653	9669	12086
13	2483	2831	3050	3268	3486	3703	4139	4575	5229	6100	7189	8279	9359	10458	13072
14	2670	3045	3279	3513	3748	3982	4450	4919	5622	6559	7730	8901	10063	11244	14055
15	2857	3285	3508	3759	4010	4260	4761	5263	6015	7017	8270	9523	10766	12030	15037
16	3043	3470	3737	4004	4271	4537	5071	5605	6406	7474	8808	10143	11467	12813	16016
17	3229	3683	3966	4249	4533	4816	5382	5949	6789	7932	9349	10765	12171	13599	16998
18	3416	3895	4186	4495	4795	5094	5694	6293	7192	8391	9889	11388	12874	14385	17981
19	3603	4108	4424	4740	5057	5373	6005	6637	7588	8849	10430	12010	13578	15171	18963
20	3789	4321	4654	4986	5319	5651	6316	6981	7978	9308	10970	12632	14281	15951	19946
21	3975	4533	4882	5231	5580	5928	6626	7334	8370	9765	11508	13252	14982	16740	20925
22	4162	4746	5111	5476	5842	6207	6937	7667	8763	10223	12049	13874	15685	17526	21907
23	4349	4959	5341	5722	6104	6486	7248	8011	9156	10682	12593	14497	16389	18312	22890
24	4535	5171	5569	5967	6365	6762	7558	8354	9547	11138	13127	15116	17090	19095	23868

TABLE OF WEIGHTS PER FOOT OF COMMON SHEET IRON.

Weight in pounds and decimal parts per foot of common sheet iron pipe from 5 to 24 inches in diameter and from No. 12 to No. 28 Birmingham wire gauge. One inch is allowed for seam in grooving or lap in riveting.

Gauge Number.	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12
Inches in Diameter. 5	827	941	1049	1127	1267	1415	1580	1820	1968	2356	2606	3266	3665	3058	4656	5351	6116
6	981	1117	1245	1338	1504	1679	1876	2161	2336	2796	3093	3877	4351	4818	5527	6352	7260
7	1136	1293	1442	1549	1741	1944	2171	2502	2704	3237	3581	4488	5036	5577	6398	7355	8404
8	1291	1469	1638	1759	1979	2209	2467	2842	3072	3678	4068	5099	5722	6336	7269	8354	9548
9	1445	1645	1834	1970	2216	2473	2762	3183	3440	4118	4556	5710	6307	7095	8140	9355	10692
10	1600	1821	2030	2181	2453	2738	3058	3523	3809	4559	5053	6321	7093	7854	9011	10356	11836
11	1755	1997	2227	2392	2690	3003	3354	3864	4177	5000	5531	6932	7779	8614	9882	11357	12980
12	1915	2179	2431	2601	2936	3277	3661	4218	4559	5457	6037	7567	8491	9402	10787	12397	14168
13	2064	2349	2619	2814	3164	3532	3945	4545	4913	5881	6506	8154	9150	10132	11624	13359	15268
14	2231	2538	2831	3041	3420	3817	4263	4912	5309	6356	7031	8812	9888	10950	12562	14437	16500
15	2385	2714	3027	3252	3657	4082	4559	5253	5678	6796	7518	9423	10574	11709	13433	15438	17644
16	2540	2890	3223	3462	3894	4346	4854	5593	6046	7237	8006	10034	11259	12468	14304	16439	18788
17	2699	3060	3412	3665	4122	4601	5139	5921	6400	7661	8475	10622	11919	13198	15142	17402	19888
18	2850	3242	3616	3884	4368	4876	5446	6274	6782	8105	8981	11256	12631	13986	16046	18441	21076
19	3010	3425	3820	4103	4614	5151	5753	6628	7164	8576	9487	11891	13343	14775	16951	19481	22264
20	3147	3601	4016	4315	4851	5415	6048	6969	7533	9017	9975	12502	14028	15534	17822	20482	23408
21	3320	3777	4212	4525	5088	5680	6344	7309	7901	9458	10462	13113	14714	16293	18693	21483	24552
22	3474	3953	4409	4736	5326	5945	6640	7650	8269	9898	10950	13724	15400	17052	19564	22484	25696
23	3635	4136	4613	4955	5572	6219	6947	8004	8651	10356	11456	14448	16112	17841	20468	23523	26884
24	3784	4305	4810	5157	5800	6474	7231	8331	9005	10780	11925	14946	16771	18571	21306	24486	27984

WEIGHT OF METALS.

Weight in lbs. of a square foot of different metals, in thicknesses varying by 1-16 of an inch.

Thickness in inches.	Wrought Iron.	Cast Iron.	Steel.	Copper.	Zinc.	Brass.	Gun Metal.	Tin.	Lead.
1-16	2.3	2.3	2.5	2.9	2.3	2.6	2.7	2.4	3.7
⅛	5.0	4.7	5.1	5.8	4.7	5.3	5.5	4.8	7.4
3-16	7.5	7.0	7.6	8.7	7.0	8.2	8.2	7.2	11.2
¼	10.0	9.4	10.2	11.6	9.4	11.0	10.9	9.6	14.9
5-16	12.5	11.7	12.8	14.5	11.7	13.7	13.7	12.0	18.6
⅜	15.0	14.1	15.3	17.2	14.0	16.4	16.4	14.4	22.3
7-16	17.5	16.4	17.9	20.0	16.4	19.2	19.1	16.8	26.0
½	20.0	18.7	20.4	22.9	18.7	21.9	21.9	19.3	29.7
9-16	22.5	21.1	25.0	25.7	21.1	24.6	24.6	21.7	33.4
⅝	25.0	23.5	25.5	28.6	23.4	27.4	27.3	24.1	37.1
11-16	27.5	25.8	28.1	31.4	25.7	30.1	30.0	26.5	40.9
¾	30.0	28.1	30.6	34.3	28.1	32.9	32.8	28.9	44.6
13-16	32.5	30.5	33.2	37.2	30.4	35.6	35.0	31.3	48.3
⅞	35.0	32.8	35.7	40.0	32.8	38.3	38.2	33.7	52.0
15-16	37.5	35.2	38.3	42.9	35.1	41.2	41.0	36.1	55.7
1	40.0	37.5	40.8	45.8	37.5	43.9	43.7	38.5	59.4

NOTE.—The weight per square foot to any gauge can easily be obtained from the above table by multiplying the weight of a square foot of the metal one inch thick by the thickness of the gauge in inches or parts of an inch.

CHAPTER VI.

MISCELLANEOUS INFORMATION.

LEGAL HOLIDAYS IN THE VARIOUS STATES.

January 1. New Year's Day.—In Alabama, Arkansas, California, Colorada, Connecticut, Dakota, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Louisiana, Maine, Maryland, Michigan, Nevada, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Vermont, Wisconsin, and Wyoming.

January 8. Anniversary of the Battle of New Orleans.—In Louisiana.

February 22. Washington's Birthday.—In Alabama, California, Colorado, Connecticut, Dakota, Georgia, Idaho, Illinois, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nevada, New Hampshire, New Jersey, New York, North Carolia, Ohio, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Virginia, Wisconsin, and Wyoming.

February 14. Mardi Gras.—In Louisiana.

March 2. Anniversary of Texan Independence.—In Texas.

March 4. Firemen's Anniversary.—In New Orleans, La.

April 19. Good Friday.—In Louisiana, Maryland, and Pennsylvania.

April 21. Anniversary of the Battle of Jacinto.—In Texas.

April 29. Memorial Day.—In Georgia.

May 30. Decoration Day.—In Arizona, California, Colorado, Connecticut, Dakota, Iowa, Illinois, Kansas, Kentucky, Massachusetts, Michigan, Nevada, New Hampshire, New Jersey, New York, Ohio, Oregon, Pennsylvania, Rhode Island, Utah, Vermont, Wisconsin Washington, and Wyoming.

June 1. Labor Day.—In Oregon.

July 4. Independence Day.—In all the States.

September (First Monday.) Labor Day.—In Alabama, California, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Maine, Maryland, Massachusetts, Michigan, Montana, Nebraska, New Hampshire, New Jersey, New York, Ohio, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, and Washington.

November 5. General Election Day.—In California, Dakota, Kansas, Maryland, Missouri, New Hampshire, New Jersey, New York, Ohio, Oregon, South Carolina, and Wisconsin.

November (last Thursday), Thanksgiving Day.—Is observed in all the States, though in Nebraska and some others it is not a statutory holiday.

December 25. Christmas Day.—In all the States, and in South Carolina the two succeeding days in addition.

Sundays and Fast Days (whenever appointed) are legal holidays in nearly all the States.

Arbor Day is a legal holiday in Idaho and Kansas, the day being set by the Governor. Arbor Day is also a legal holiday in Rhode Island, but does not affect the payment of notes, etc.

In Nebraska there are no legal holidays established by statute. The same is the case in New Mexico.

Every Saturday after 12 o'clock noon is a legal holiday in New York.

ANTIDOTES TO POISONS.

In nearly all cases of poisoning the first thing to do is to excite copious vomiting by means of a powerful emetic, the action being promoted by large draughts of lukewarm water, tickling the throat with the finger, etc. If the vomiting can not be brought on by this means the stomach-pump must be resorted to, but not till the simple methods have been tried. The vomiting should be kept up by giving albuminous liquids such as milk and water, barley water, or similar substances, always administered when lukewarm. After the vomiting has removed the poisonous substance, a mild aperient draught may be given, and nervous exhaustion allayed by very small doses of ether or ammonia, or draughts of wine or hot spirits and water. Generally speaking, a tablespoonful of the flour of mustard mixed with warm water will serve as an effective emetic. Whenever medical aid is accessible it should be called immediately to a case of poisoning. For special antidotes, we take the following directions from a chemical journal, giving the substances most useful in counteracting the effects of poisonous chemicals: "For phenic, sulphuric, muriatic, nitric or nitro-muriatic acids, creosote, tincture of iodine, or phosphorus, use the white of an egg well beaten up in water, and a teaspoonful of mustard in warm water. In case sulphuric, nitric, or muriatic acid has been swallowed, it is necessary to take lime mixed with as small a quantity of water as possible. For chronic acid, the

chromates and colors that have chromium for a base, the compounds of copper, and such preparations as have antimony for a base (such as tartar emetic), and the compounds of murcury and zinc, use the white of eggs in abundance, and as an emetic mustard, which, however, is useless if the poisoning has been done by tartar emetic. For ammonia, soda, potassa, the silicates and the alkaline hydrosulphates, use vinegar, and afterward oil or milk. For prussic acid and its salts, the cyanides of potassium and mercury, the sulpho-cyanides, oil of bitter almonds, or nitrobenzine, pour water on the patient's head or spinal column, and put mustard plasters on the feet and the stomach. Do not let the patient go to sleep. For ether, petroleum, benzole, fruit essences, and concentrated alcohol, take strong mustard as an emetic, with much warm water, cold baths, and fresh air. Keep the patient awake. For the compounds of baryta or lead, use mustard as an emetic, with warm water, Epsom salts or Glauber's salts in water. For arsenic and its compounds, use mustard and dialyzed iron with magnesia, and afterward oil, milk, or mucilaginous liquids. For oxalic acid and its salts, use lime or lime water, and afterward castor oil. For nitrate of silver, use kitchen salt dissolved in water, and mustard as an emetic. For the nitrous fumes from the manufacture of the nitrate of iron, or of sulphuric acid, take acetic acid as strong as can be endured, in small quantities at a time.

USEFUL SUGGESTIONS IN CASES OF ACCIDENT TO MECHANICS.

BLEEDING.—If blood spurts from wound, an artery is divided; bind limb tightly above wound with India-rubber tubing, strap, handkerchief, or scarf, or bend the

limb forcibly at next joint above wound; or press flat hand or stone where blood is flowing. If blood flows freely, but does not spurt, a vein is divided; then apply same measures as in case of wounded artery, but below the wound. If scalp wounded, make a pad of cloth or waste, and bandage very tightly over wound with folded pocket handkerchief.

Burns and Scalds.—Apply lint, cotton wool, or waste, soaked in oil, or oil and lime water, and bind the same on with handkerchief. If necessary to remove clothes, cut them off by running knife or scissors along seams.

Broken Leg.—Pull on leg steadily and firmly until it is of same length as sound one. Roll up a coat or empty sack into form of a cushion; carefully place leg upon it; then bind the two together with scarfs or handkerchiefs. Do not lift patient from the ground until stretcher is close at hand. Take great pains, by careful lifting, to prevent broken bone coming through skin.

Broken Thigh.—Take hold of ankle, and, by steady traction, pull limb to same length as sound one; another person must then tie knees together, and afterward the ankles. Both limbs should then be laid over a sack of straw, or folded coat, so as to bend the knees. Patient should on no account be moved until stretcher is close at hand.

Broken Arm.—Pull arm to length of sound one. Apply two splints, one outside, and other inside, binding them firmly on with pocket handkerchiefs. The best splints are made by folding newspapers to necessary length, binding them above and below seat of fracture; anything hard and light, of suitable size, would act equally well, for instance, wood, pasteboard, twigs, leather, etc.

Broken Ribs.—Cause intense pain when patient breathes; bind roller towel firmly round chest, fastening with pins, or sewing.

Broken Collar-bone.—Bend arm over front of chest; place it in a sling; bind it in that position by scarf going round chest, outside sling.

Dog Bites.—Tie a handkerchief or cord tightly round limb above wound; suck the wound.

Flesh Wounds.—Uncover wound; wash it with clean water; wring out a clean handkerchief, or some lint, in cold water, and lay it over the wound. Then, bind in position with handkerchief.

Fainting.—From heat, exhaustion, or loss of blood. Keep head low; undo clothing about neck; plenty of fresh air; dash cold water on face and chest; smelling salts, carefully used; a little brandy, when sensibility has returned, excepting in cases of sunstroke, and where means have not been taken to prevent further bleeding.

Insensibility.—From blows or wounds on head. Send at once for doctor or take patient to hospital, keeping him on his back, with head raised; undo clothing round neck; do not give brandy.

Insensibility.—From being buried in falls of earth, or breathing foul gas; proceed as in drowning.

Fits.—1. If snoring and face flushed, undo clothing round neck, keep head raised, and dash cold water on top of head; hot water bottles to feet. Do not give brandy.

2. If foaming at mouth and convulsed, undo clothing, apply smelling salts, and prevent patient hurting himself until conscious again.

Drowning.—Send for doctor, blankets, and dry clothing. Take off wet clothes from upper part of body. Lay patient on his back, with his head on a

folded coat for cushion. Draw tongue out of mouth and hold it there. A second person kneels at patient's head and takes hold of both his arms just below the elbows. He then draws them upward over the patient's head, and holds them in that position until he counts two; this draws air into the lungs. He then lowers arms to sides again and presses them firmly inwards, holding them there until he has again counted two; this forces air out of the lungs. Go on doing this until doctor arrives, or until patient breathes naturally. As soon as he does so, rub the limbs in an upward direction with the dry hands, or better still with hot flannels. Put patient to bed between blankets, surrounded with hot water bottles. May give him wine or brandy when quite sensible.

RUPTURE, or "break of the body."—Try and push it back with flat hand: keep man on his back. Cold wet clothes laid over rupture will, perhaps, aid its return.

USEFUL SHOP HINTS.

In brazing file the edges clean and bright, cover with spelter and powdered borax, and expose in a clear fire to a heat sufficient to melt the solder.

To bronze copper, clean the surface, then brush it over with a solution of sulphate of iron, acetate of copper, or peroxide of iron; heat it cautiously and gradually, rub off the powder and examine. If not a good bronze color repeat the process.

For bronze paint for iron take ivory black one ounce, crome yellow one ounce, crome green two pounds. Mix with raw linseed oil and add a little Japan to dry it.

For brassing small articles take one quart of water and add half an ounce each of sulphate copper and pro-

tochloride of tin. Stir the articles in the solution until the desired color is obtained. Use the sulphate of copper alone for copper color.

To frost brass work, boil in caustic potash, rinse in clean water, and dip in nitric acid till all oxide is removed; then wash quickly, dry in boxwood sawdust, and lacquer while warm. This will give brass an ornamental finish.

For washing brass with tin boil together six pounds of cream tartar, four gallons of water and eight pounds of grain tin or tin shavings, for half an hour in porcelain-lined vessel; put the clean brassware in the boiling liquid for a few minutes or until properly coated.

Tin and tin alloys, after careful cleansing from oxide and grease, are handsomely and permanently bronzed if brushed over with a solution of one part of sulphate copper (bluestone), and one part of sulphate of iron (copperas) in twenty parts of water. When this has dried, the surface should be brushed with a solution of one part of acetate of copper (verdigris) in acetic acid. After several applications and dryings of the last named, the surface is polished with a soft brush and bloodstone powder. The raised portions are then rubbed off with soft leather moistened with wax and turpentine, followed by a rubbing with dry leather.

The best paint for galvanized iron where dark color is not objectionable is common asphalt dissolved in turpentine or benzine. It is extremely tenacious, dries soon and becomes very hard and insoluble by action of sunlight. It is flexible and very durable.

Good varnish, one-half gallon; boiled linseed oil, one-half gallon; add red lead sufficient to bring to the consistency of common paint. Apply with brush. Applicable to any kind of iron work exposed to the weather.

For varnish for bright iron work, dissolve three pounds of rosin in ten pints boiled linseed oil, and add two pounds of turpentine.

A coat of varnish made in the proportion of two ounces of shellac to nine ounces of alcohol, will prevent brass from tarnishing.

TO ATTACH LABELS TO TIN.

1. If the paper is well sized and will resume its original color when the paste is dry use a solution of balsam of fir, 1 part, in oil of turpentine, 2 or 3 parts.

2. Soften 1 part of good glue in water, then pour off the excess, and boil it with 8 parts of strong vinegar (about 8 per cent). Thicken the liquid, while boiling, with enough of fine wheat flour or dextrin.

3. Make starch paste and add to it while warm a little Venice turpentine, so that the latter will become evenly distributed through it.

4. Add to starch paste, or any other similar aqueous paste (except that made from gum Arabic) some solution of shellac in borax. The quantity may be easily determined by trial.

5. Paint the spot where the label is to be put with a solution of tannin and let it dry. Affix the label previously gummed and wetted.

6. Paint the spot over lightly with a camel's hair brush dipped into chloride of antimony.

7. Make a dilute solution of white gelatine, or, better, of isinglass, about 1 in 20. This is said to adhere without the addition of anything else.

8. To mucilage of acacia, starch, dextrin, or tragacanth paste add a little ammonia.

9. Or add a little tartaric acid. A trifle of glycerine may be added besides.

10. Mucilage of gum Arabic may be made much more adhesive by heating 100 parts of it with 2 parts of sulphate of aluminum, previously dissolved in hot water, to boiling, and then allowing to settle. A little tartaric acid and some glycerine added to the clear liquid after it is decanted will improve it.

11. Make a mixture of mucilage of tragacanth, 10 parts, and flour, 1 part.

SIMPLE TESTS FOR IMPURE WATER.

The presence of organic impurity in water can be detected by dissolving some loaf sugar in it, and then, after putting in a tight stopper, allowing it to stand in a warm, well-lighted room for a few days. If it becomes turbid, there are certainly organic impurities in it; if it remains clear it is pure and safe to drink. To test the presence of earthy matters, take litmus paper dipped in vinegar, and if, on immersion, the paper returns to its true shade, the water does not contain earthy matter or alkali. If a few drops of sirup be added to water containing an earthy matter, it will turn green. To ascertain if the water contains iron, boil a little nut gall and add to the water. If it turns gray or slate black iron is present. Or dissolve a little prussiate of potash, and if iron is present it will turn blue. The presence of carbonic acid may be ascertained, even in very small quantities, thus: Take equal parts of water and clear lime water. If combined or free carbonic acid is present, a precipitate is formed, to which, if a few drops of muriatic acid be added, an effervescence commences. To detect magnesia, boil the water to a twentieth part of its weight, and then drop a few grains of neutral carbonate of ammonia into a glass of it, and a few drops

of phosphate of soda. If magnesia be present it will fall to the bottom. We can ascertain the presence of even a very small quantity of lime if into a glass of water we put two drops of oxalic acid and blow upon it. If it gets milky lime is present. The presence of any acid can be shown by dipping into the water a piece of litmus paper. If it turns red there must be acid. If it precipitates on adding lime water it is carbonic acid. The unfailing test for hard or soft water is to take a little good soap and dissolve it in alcohol. A few drops of this in a vessel of water will turn it quite milky if it is hard; if it is soft it will remain clear.

ALLOYS.

A combination of copper and tin makes bath metal; of copper and zinc makes bell metal; of tin and copper makes bronze metal; of tin, antimony, copper and bismuth makes britannia metal; of tin and copper makes cannon metal; of copper and zinc makes Dutch gold; of copper, nickel and zinc with sometimes a little iron and tin, makes German silver; of gold and copper makes standard gold; of gold, copper and silver makes old standard gold; of tin and copper makes gun metal; of copper and zinc makes mosaic gold; of tin and zinc makes pewter; of lead and a little arsenic makes sheet metal; of silver and copper makes standard silver; of tin and lead makes solder; of lead and antimony makes type metal; of copper and arsenic makes white copper.

NICKEL ALLOYS.

The following alloys have been found useful: Nickel aluminum, composed of 20 parts nickel and 8 parts aluminum, used for decorative purposes; rosin, com-

posed of 40 parts nickel, 10 parts silver, 30 parts aluminum, and 20 parts tin, for jewelers' work; sun-bronze composed of 60 parts cobalt, 10 parts aluminum, 40 parts copper; metalline, 35 parts cobalt, 25 parts aluminum, 10 parts iron and 30 parts copper.

COST OF A PATENT IN DIFFERENT COUNTRIES.

United States:	
Preliminary examination	$ 5 00
Cost of drawing	5 00
First Government fee (in every case the same)	15 00
Total outlay to secure filing of an application	$25 00
Final Government fee	20 00
Attorney's fee	20 00
Total minimum cost of patent	$65 00
Canada	$40 00
German	60 00
Great Britain	60 00
France	60 00
Italy	60 00
Austria	60 00
Belgium	60 00

WEIGHT OF METALS.

Zinc weighs .253 pounds per cubic inch.
Cast iron weighs .26 pounds per cubic inch.
Tin weighs .263 pounds per cubic inch.
Wrought iron weighs .28 pounds per cubic inch.
Steel weighs .282 pounds per cubic inch.

Brass weighs .3 pounds per cubic inch.
Copper weighs .32 pounds per cubic inch.
Lead weighs .41 pounds per cubic inch.

TO CALCULATE RADIATING SURFACE.

Add together the square feet of glass in the windows; the number of cubic feet of air required to be charged per minute, and one-twentieth the surface of external wall and roof; multiply this sum by the difference between the required temperature of the room and that of the external air at its lowest point, and divide the product by the difference in temperature between the steam in the pipes and the required temperature of the room. The quotient is the required radiating surface in square feet. Each square foot of radiating surface may be depended upon in average practice to give out three heat units per hour for each degree of difference in temperature between the steam inside and the air outside, the range under different conditions being about 50 per cent above or below that figure.

SHRINKAGE OF CASTINGS.

The allowance for shrinking in castings should be for each foot in length:—

	Parts of an inch.
For cast iron pipes	.125—⅛
" beams and girders	.1—1-10
" cylinders, large	.094—3-32
" " small	.06—1-16
Brass	.17—3-16
Lead	.31—5-16
Zinc	.25—¼
Copper	.17—3-16

THE WEAR AND TEAR OF BUILDING MATERIALS.

At the tenth annual meeting of the Fire Underwriters' Association of the Northwest, held at Chicago in September, 1879, Mr. A. W. Spaulding read a paper on the wear and tear of building materials, and tabulated the result of his investigations in the following form:

Material in Building.	Frame dwelling.		Brick dwelling (shingle roof.)		Frame store.		Brick store (shingle roof.)	
	Average life, Years.	Per cent of depreciation per annum.	Average life, Years.	Per cent of depreciation per annum.	Average life, Years.	Per cent of depreciation per annum.	Average life, Years.	Per cent of depreciation per annum.
Brick	..	..	75	1⅛	..	..	66	1½
Plastering	20	5	30	3⅓	16	6	30	3⅓
Painting, outside	5	20	7	14	5	20	6	16
Painting, inside	7	14	7	14	5	20	6	16
Shingles	16	6	16	6	16	6	16	6
Cornice	40	2½	40	2½	30	3⅓	40	2½
Weather-boarding	30	3⅓	..	..	30	3⅓	..	..
Sheathing	50	2	50	2	40	2½	50	2
Flooring	20	5	20	5	13	8	13	8
Doors, complete	30	3⅓	30	3⅓	25	4	30	3⅓
Windows, complete	30	3⅓	30	3⅓	25	4	30	3⅓
Stairs and newel	30	3⅓	30	3⅓	20	5	20	5
Base	40	2½	40	2½	30	3⅓	30	3⅓
Inside blinds	30	3⅓	30	3⅓	30	3⅓	30	3⅓
Building hardware	20	5	20	5	13	8	13	8
Piazzas and porches	20	5	20	5	20	5	20	5
Outside blinds	16	6	16	6	16	6	16	6
Sills and first floor joints	25	4	40	2½	25	4	30	3⅓
Dimension lumber	50	2	75	1 ⅓	40	2½	66	1½

These figures represent the averages deduced from the replies made by eighty-three competent builders unconnected with fire insurance companies in twenty-seven cities and towns of the eleven Western States.

A QUICK METHOD OF FINDING INTEREST.

Rule.—1st. Divide the principal by 12, and multiply the result by the rate per cent. expressed decimally; this gives the interest for one month. 2d. Multiply the years by 12, and add the number of months, then place ⅓ of the number of days to the right as a decimal.

Multiply 1st and 2d results, gives the interest.

WEIGHT OF BUILDINGS.

It has been calculated that the pressure per square foot of the superstructure upon the foundation walls of a few of the best known buildings is as follows:

Dome of United States Capitol at Washington	13,477	pounds
Girard College, Philadelphia	13,440	"
St. Peter's, Rome	33,330	"
St. Paul's, London	39,450	"
St. Genevieve, Paris	60,000	"
Le Toussaint, Angers	90,000	"

while the pressure upon the earth per square foot in the case of St. Paul's, London, is 42,950 pounds.

COST OF PUBLIC BUILDINGS.

An experienced architect and surveyor, on the 19th of February, 1879, prepared, and presented to Gen. Meigs, Quartermaster-General, the estimate which follows of the cost of various public and private buildings in this country, the comparison being by cubic feet, external dimensions:

Sub-Treasury and Postoffice, Boston, Mass	$2,080,507
United States Branch Mint, San Francisco, Cal	1,500,000
Custom and Court House and Postoffice, Cairo, Ill	271,081
Custom and Court House and Postoffice, Columbia, S.C.	381,900
United States building, Des Moines, Iowa	221,437

United States building, Knoxville, Tenn	398,847
United States building, Madison, Wis	329,389
United States building, Ogdensburg, N. Y	216,576
United States building, Omaha, Neb	334,900
United States building, Portland, Me	392,215
German Bank, Fourteenth street, Newport, R. I	475,000
Staats Zeitung, New York City	475,100
Western Union Telegraph, New York City	1,400,000
Masonic Temple, New York City	1,900,000
Centennial building, Shepherd's, corner Twelfth and Pennsylvania Avenues, Washington, D. C	246,073
Add to this the United States National Museum, fire-proof building, at Washington, D. C	250,000

RELATIVE HOLDING POWER OF WIRE AND CUT NAILS.

Test made by a committee appointed by the Wheeling Nail Manufacturers.

	NUMBER OF NAILS IN POUND.		POUNDS REQUIRED TO PULL NAILS OUT.	
	Cut.	Wire.	Cut.	Wire.
20d.	23	35	1,593	703
10d.	60	86	908	315
8d.	90	126	597	227
6d.	160	206	383	200
4d.	280	316	286	123

This test showed the relative value of a pound of each kind to be as follows:

1 lb. of 20d. cut nails equals 1.40 lbs. of wire nails.
1 " 10d. " " 2.01 " "
1 " 8d. " " 1.87 " "
1 " 6d. " " 1.49 " "
1 " 4d. " " 2.06 " "

In obtaining the above results, two tests were made of the 8d. cut nails, and four of the 8d. wire nails; three tests each were made of the 6d. and 4d. cut nails, and 6d. and 4d. wire nails, and the average is shown.

The committee report as the result of their experi-

ments that $1.00 of cut nails will give the same service as $1.78 in wire nails, if at the same price per pound.

Very thorough tests of the comparative holding power of wire nails and cut nails *of equal lengths and weights* were made at the United States arsenal, Watertown, Mass., in November and December, 1892, and January, 1893. Fifty-eight series of tests were made, each series comprising ten pairs cut nails and wire nails making a total of 1,160 nails tested. From forty series comprising forty sizes of nails driven in spruce wood, it was found that the cut nails showed an average superiority of 60.50 per cent.; the common nails showing an average superiority of 47.51 per cent., and the finishing nails an average of 72.22 per cent.

In eighteen series, comprising six sizes of *box* nails driven into pine wood, in three ways the cut nails showed an average superiority of 99.93 per cent.

In no series of tests did the wire nails hold as much as the cut nails.

CHAPTER VII.

METALS.

METALS AND THEIR PROPERTIES; ALLOYS; SOLDERS; SOLDERING FLUXES.

In the following pages a mass of valuable data will be given concerning those metals used most largely in plate or sheet.

As it is necessary to frequently refer to the various paragraphs of this chapter, each paragraph is numbered.

(1) Metals are natural elementary substances, as far as is known. They are *opaque* (not transparent), reflect light from their polished surfaces, and have a characteristic lustre, known as the *metallic lustre*. With the exception of mercury, they are all solid at the ordinary temperature of the atmosphere.

(2) Silver, tin, lead, mercury, antimony, zinc, cadmium, and bismuth, have a whitish or grayish color. Gold stands alone as a metal having a yellow color; copper is the only red metal.

(3) Metals differ widely in their behavior under the influence of heat; some, as tin and lead, are fusible below red heat; others, as copper, gold, and silver, fuse readily in ordinary furnaces; nickel, iron, and manganese fuse with great difficulty; platinum is practically infusible. Arsenic, cadmium, zinc, and mercury are *volatile*, that is, vaporise easily. An interesting example of volatility is that of zinc, which when at a bright red heat takes fire, burns with a greenish flame, and *oxidises*

(unites with the oxygen gas of the atmosphere), being thereby converted into a dense white flocculent substance called formerly 'philosopher's wool.'

(4) The fracture of metals is often characteristic; we get crystalline, granular, fibrous, silky, and other fractures.

PROPERTIES; SPECIFIC GRAVITY; MELTING-POINTS.

Metals have various properties. Some remarks on these, and other particulars respecting metals, now follow.

(5) *Malleability.*—A property which is possessed by metals in varying degree is that of malleability, that is, of permitting extension of surface without rupture, by, for example, hammering, pressure, or rolling. Gold, which is capable of being hammered into leaves of extreme thinness, is the most malleable of all metals. Other metals, though malleable to a considerable degree, require to be *annealed* (heated red and allowed to cool down slowly) once or even several times during the operation of rolling out, or extending by the hammer as in raising and stretching. Copper is an example; though, curiously enough, copper is equally malleable whether, after heating, it is allowed to cool slowly or is cooled suddenly by dipping while at red heat in cold water. Zinc is in its most malleable condition at a temperature a little above the boiling-point of water; when less than half as hot again as this, it is brittle and unworkable.

(6) Of the theory of annealing nothing definite appears to be known; but it is supposed that on rolling out or hammering a piece of metal the particles or molecules of which the metal is composed, become strained and disarranged ('the grain closed'), and the

metal is hardened; and that on heating, the metal expands, and the strain being removed, the molecules rearrange themselves. This, however, does not explain many matters connected with annealing; for example, why one heated metal is hardened by being suddenly dipped in cold water, and another metal softened when treated in the same manner.

The following, which illustrates the effect of 'hammer hardening' on iron, may be of interest:—

(7) In 1854, at the meeting of the British Association in Liverpool, a paper on the crystallisation of iron under certain circumstances was read by Mr. Clay (Mersey Iron and Steel Works), who stated that he selected a piece of good, tough, fibrous bar-iron, which he heated to a full red heat, and then hammered by light, rapid, tapping blows, until it was what is called 'black-cold.' After complete cooling he broke it, and found that the structure of the iron was entirely changed, and that, instead of bending nearly double without fracture, as it should have done, and breaking with a fine silky fibre when fracture did occur, an entire alteration had taken place, and the bar was rigid, brittle, and sonorous, incapable of bending in the slightest degree, and breaking with a glassy, crystallised appearance. By simply heating the bar to full red-heat again, the fibre was restored exactly as before.

(8) *Tenacity*.—The property in metals of resisting being torn asunder by a tensile or stretching force, is called *tenacity*.

The tenacity of metals varies with their purity and molecular condition, as due to modes of treatment or preparation: for example, the tenacity of steel is much influenced by its 'temper,' and that of cast iron made by the *cold-blast* process is greater than when the process is that of the *hot-blast*.

(9) *Ductility.*—The property of being permanently lengthened by a tensile or stretching force, as in wire drawing, is called *ductility.* All the malleable metals are more or less ductile, though the most malleable metals are not necessarily the most ductile; ductility being influenced more by tenacity than by malleability.

The table shows how some of the metals, starting from gold(see 'Malleability', above § 6), rank under the headings given.

Malleability.	*Ductility.*	*Tenacity.*
Gold	Gold	Steel
Silver	Silver	Iron
Copper	Platinum	Copper
Tin	Iron	Platinum
Platinum	Copper	Silver
Lead	Aluminum	Gold
Zinc	Zinc	Zinc
Iron	Tin	Tin
Nickel	Lead	Lead

(10) *Conductivity.*—Of all solids, metals are the best conductors of heat. The order of conductivity for a few important metals, beginning with the best conductors is—silver, copper, gold, tin, iron, lead, platinum, and bismuth.

(12) *Welding.*—An important property of some of the metals is that pieces can be 'welded' together, that is, incorporated with each other. Iron at a white heat is in a pasty condition and can be 'welded'; that is, if two white-hot and clean surfaces of iron be brought into contact and pressed or hammered together, they thus are 'welded,' that is, become part of one and the same mass. If lead and gold in a fine state of division be strongly pressed together at the ordinary temperature of the atmosphere, they will form one mass.

(12) *Hardness.*—The comparative hardness of metals is usually estimated by the force required to draw the metals into wires of equal diameter. In order of hardness we have—steel, iron, copper, silver tin, antimony, and lead.

(13) *Specific Gravity.* Some substances are, in their nature, more weighty bulk for bulk than others. Thus, a cubic inch of lead is heavier than a cubic inch of iron; and a cubic inch of iron than a cubic inch of water.

By their *specific gravity*, the weights, relatively to each other, of substances, are known. The standard of comparison is an equal bulk of pure distilled water, and if the specific gravity of a body is, say 2, this means that it is twice as heavy as the same bulk of water.

The specific gravity of platinum is 21; platinum therefore bulk for bulk is 21 times heavier than water.

The specific gravity of antimony is 6·7, and a cubic foot of pure distilled water weighs very nearly 1000 ounces. Therefore a cubic foot of antimony weighs 6·7 times 1000 ounces, that is 6700 ounces.

Knowing the specific gravity of a substance, we can find the weight of any volume of it, by multiplying the given volume in cubic inches, by its specific gravity, and by 62·4 the weight in lbs. of a cubic foot (1728 cubic inches) of water, and dividing by 1728. Thus the weight of 48 cubic inches of cast copper, the specific gravity of which is 8·6, is

$$\frac{48 \times 8{\cdot}6 \times 62{\cdot}4}{1728}$$, is, that is to say, 14·9 lbs.

As the relative weights of equal volumes of metals have often to be taken into consideration in using metals for constructive purposes, for example, in the

covering of roofs, where weight is sometimes a matter of importance, a table of specific gravities follows:

TABLE OF SPECIFIC GRAVITIES AND MELTING-POINTS.

Metals.	Specific Gravities.	Melting-points. (Centigrade.)	Authority for Melting-points.
Antimony	6·7	432	Buillet.
Bismuth	9·8	268·3	Reimsdyk.
Copper (cast)	8·6	1054	Violle.
" (wrought)	8·8		
Steel	7·8	1300 to 1400	Buillet.
Cadmium	8·6	320·7	Person.
Iron (wrought)	7·8	1500 to 1600	Buillet.
Lead	11·36	326·2	Person.
Tin	7·29	232·7	Person.
Zinc	7·19	433·3	Person.
Aluminum	2·67	1045	Violle.
Nickel	8·30	1450	Pictel.
Platinum	21·25	1775	Violle.

The melting-points of the metals named are added to the table, as it is often useful to be able to refer to these. The degrees of heat are according to the Centigrade thermometer. This portion of the table is taken from 'Melting and Boiling Point Tables,' by Thos. Carnelley, 1885.

We now proceed to notice more particularly the metals iron (including cast iron and steel), tin, zinc and copper.

IRON AND STEEL.

(14) Iron in a state of purity is comparatively little known; the ores of it are various and abundant. In its commercial forms, as plate or sheet, bar, and cast iron, it is well known. As sheet it can be cut into patterns and bent into desired forms; as bar it can be made hot and 'wrought,' that is, shaped by means of the hammer; and when molten it can be run or cast into all

sorts of shapes. Cast iron is brittle, crystaline in fracture (§4), and not workable by the hammer. In sheet and bar form, iron is malleable, mostly (fibrous in fracture, and capable of being welded (§11). The presence of impurities in bar iron, that is, the presence of substances not wanted in it at the time being, seriously affects its malleability. Thus the presence of phosphorus, or tin, renders it brittle when cold ('cold-short'), and the presence of sulphur makes it unworkable when hot ('hot-short'). Iron quickly *rusts* (oxidises, §3) if exposed to damp air, as in the case of iron exposed to all weathers; or to air and water, as with vessels in which barely sufficient water is left to cover the bottoms, the rusting (oxidation) being then much more rapid than when the vessels are kept full. Heated to redness and above, 'scale' (oxide of iron) rapidly forms and interferes greatly with welding. It is impossible to enter here into any consideration of the processes by which iron is prepared from its ores. To two modern processes, however, we shall presently have particularly to refer.

(15) The effects of the presence of several foreign substances in iron as impurities has just been alluded to, but the presence in it of 'carbon' we have not spoken of. This is a substance which in its crystalline form is known as the diamond, and in its uncrystalline form as charcoal. The presence of charcoal in iron destroys its malleability, but at the same time gives to it properties various, so remarkable and useful to mankind, that to say, as a defect, of a piece of iron with carbon in it, that it is not malleable, is simply equivalent to saying when we have a piece of brass, that it is not a piece of copper. Quite the reverse of being 'matter in the wrong place,' carbon in iron furnishes a compound so valuable

on its own account, so entirely of its own kinds (in the plural because its kinds are several), that, if there were other substances not metals, the compounding of which with a metal gave products at all resembling those of iron and carbon, then all such compounds would form a class of their own. The iron and carbon compound, so valuable on its own account, so entirely of its own however, stands inconveniently alone. There we shall not leave it, but as aiding the full comprehension of it, notwithstanding that we define *alloys* (§4) as compounds of *metals*, shall consider it not as outside but as within this class of substances, as well as also shall speak of iron as being *alloyed* with it. We shall deal with it, however, under the present heading, treating compounds of actual methods later on.

(16) Iron is alloyed with carbon in proportions varying from say ½ to 5 per cent. When in the proportion of from 2 per cent. upwards, the compound is cast iron, that is, iron suitable for casting purposes; in other proportions it is known as steel. In cast iron the metallic appearance is somewhat modified; in steel it is maintained. Originally steel was made by the addition of carbon to manufactured iron, and the word had then a fairly definite signification; meaning a material of a high tensile strength; that by being heated dull red and suddenly cooled could be made so hard that a file would not 'touch' it, that is, would slide over it without marking it; and that could have that hardness modified or '*tempered*' by further application of heat. But with the introduction of the Bessemer process of steel making, and of the Siemens' process of making steel direct from the ores, processes by which any desired percentage of carbon can be given, the signification of the word has become enlarged, and now includes all

alloys of iron and carbon between malleable iron and cast iron; except that the term '*mild*' steel is sometimes applied to those alloys that approach in qualities to malleable iron. Steel plates are now produced equal in toughness, and it is said even excelling the best '*charcoal*' plates, and as they are much cheaper, the old charcoal-plate-making process is very generally giving way to the direct process. In practice, however, these plates are found to be more *springy* than good charcoal plates, and not so soft and easy to work.

(17) As iron is very liable to rust, surface protection is given to it by a coating of tin, or of an alloy of lead and tin, (lead predominating), or of zinc. Plates coated with tin are termed '*tin*' plates; with lead and tin have the name of *terne* plates, and if coated with zinc are said to be 'galvanised.' Terne plates are used for lining packing-cases, also for work to be japanned. Usual sizes of tin and terne plates are $14'' \times 10''$, $20^{\circ} \times 14''$, $20'' \times 28''$, and they are made up to $40'' \times 28'$.

(18) Large iron sheets of various gauges coated with tin and having the same appearance as a 'tin' plate are called *Manchester plates*, and sometimes *tinned iron*. But the latter is more generally applied to sheets of iron which are coated with lead and tin, and are dull like terne plates.

(19) Iron coated with zinc is not so easily worked as when ungalvanised. In galvanising, the zinc 'alloys' with the surface of the iron, and this has a tendency to make the iron brittle. Galvanised iron is useful for water tanks as the zinc coating prevents rust better than a tin coating. Owing to the ease with which zinc is attacked by acids, galvanised iron is not suitable for vessels exposed to acids or acid vapours.

COPPER.

(20) This, the only red metal (§ 3), is malleable, tenacious, soft, ductile, sonorous, and an excellent conductor of heat. For this reason, and because of its durability, it is largely made use of for cooking utensils. It is found in numerous states of combination with other constituents, as well as 'native' (uncombined). Its most important ore is *copper pyrites*. Copper melts at a dull white heat and becomes then covered with a a black crust (oxide). It burns when at a bright white heat with a greenish flame. No attempt explanation of its manufacture will here be made, as any description not lengthy would be simply a bewilderment. For the production of sheet copper it is first cast in the forms of slabs, which are rolled, and then annealed and re-rolled, this annealing and re-rolling being repeated until the copper sheet is brought down to the desired thickness. In working ordinary sheet copper, it is hammered to stiffen it, and 'close the grain.' *Hand-rolled* copper is, however, produced that does not require hammering.

(21) In the course of the manufacture of copper it undergoes a process termed '*poling*' to get rid of impurities. We mention this because we shall find (§ 38) a similar process gone through in preparing solders. The poling of copper consists in plunging the end of a pole of green wood, preferably birch, beneath the surface of the molten metal, and stirring the mass with it. Violent ebullition takes place, large quantities of gases are liberated, and the copper is thoroughly agitated. It is doubtful if this poling process is fully understood, for, though it is quite obvious that there may be insufficient poling ('*underpoling*'), it is not easy to explain

'*overpoling*.' But overpoling, as a fact, is fully recognised in the manufacture of copper, and the metal is brittle both if the polling is too long continued or not long enough. If duly poled, the cast slab when set displays a comparatively level surface; if underpoled a longitudinal furrow forms on the surface of a slab as it cools; if overpoled, instead of a furrow, the surface exhibits a longitudinal ridge. Copper, duly poled, is known as 'best selected,' and as 'tough cake' copper.

ZINC.

(22) Of this metal, known also very commonly as 'spelter,' *calamine* is a very abundant ore; another abundant ore is *blende*. The metal is extracted from its ores by a process of distillation, the metal volatilising (§ 3) at a bright red heat, and the vapour, passing into tubes, condenses, and is collected from the tubes in powder and in solid condition. If required pure, further process is necessary. This metal does not appear to have been known until the sixteenth century. Henkel, in 1741, was the first, at least in Europe, who succeeded in obtaining zinc from calamine. Zinc is hardened by rolling, and requires to be annealed at a low temperature to restore its malleability. Until the discovery of the malleability of zinc when a little hotter than boiling water, it was only used to alloy copper with, and sheet zinc was unknown. Zinc expands 1-340th by heating from the freezing to the boiling point of water. The zinc of commerce dissolves readily in hydrochloric and in sulphuric acid; pure zinc only slowly. If zinc is exposed to the air, a film of dull grey oxide forms on the surface. It suffers afterward little further change. Zinc alloys with copper and tin, but not with lead; it

also alloys with iron, for which it is largely used as a coating; iron so coated being known as 'galvanised' iron (§ 17).

LEAD.

(23) Another metal that is prepared in sheet is lead. This metal was known in the earliest ages of the world; it is soft, flexible, and has but little tenacity. One of its principal ores is *galena*. Being a soft metal, it is worked (*'bossed'*) by the plumber into various shapes by means of special tools, which often saves the making of joints. As it is comparatively indestructible under ordinary conditions, it is largely used for roofing purposes and for water cisterns. It is also used for the lining of cisterns for strong acids, in which case the joints are not soldered in the ordinary way with plumber's solder, but made by a process termed *'autogenous soldering'* or *'lead burning.'* Lead prepared in sheet by casting is known as *cast* lead, but when prepared by the more modern method of casting a small slab of the metal and then rolling it to any desired thickness is called *milled* lead.

ALLOYS.

(24) An alloy is a compound of two or more metals. Alloys retain the metallic appearance, and whilst closely approximating in properties to the metals compounded, often possess in addition valuable properties which do not exist in either of the constituent metals forming the alloy. An alloy of copper and zinc has a metallic appearance and working properties somewhat similar to those of the individual metals it is made up of, and so with an alloy of gold, or silver, and a small percentage of copper. But the latter alloys have

the further property of hardness, making them suitable for coinage, for which gold, or silver, unalloyed, is too soft. Like to this addition of copper to gold or silver is the addition of antimony to lead and to tin, by which alloys are obtained harder though more brittle than ether lead or tin by itself. The alloy of lead and antimony is used for printer's type, for which lead alone is too soft.

(25) Alloys are often more fusible than the individual metals of which they are composed. Thus while lead melts at 326° C., tin at 233° C., bismuth at 268° C., and cadmium at 321° C., an alloy of 8 parts bismuth, 4 tin, and 4 lead, forms what is technically known as a 'fusible' alloy, meaning an alloy very readily fusible, the particular alloy stated melting indeed at 95°C., that is, below the boiling-point of water. The addition of a little cadmium to the above forms a still more 'fusible' alloy, called Wood's alloy, which melts at about 65° C.

(26) We give here the names of some of the more important alloys, with those of the metals of which they are made up.

Bronze	Copper and tin.
Bull-metal	
Gun-metal	
Speculum-metal	
Brass	Copper and Zinc.
Dutch-metal	
Muntz' metal	
Hard solders	
German silver	Copper, zinc, and nickel.
Britannia metal	Tin, antimony, copper, bismuth, and zinc.
Pewter	Lead and tin.
Soft solders	
Type metal	Lead and antimony.

ALLOYS OF COPPER AND TIN.

(27) Alloys of copper and tin are known as bronze, gun-metal, speculum-metal, etc. Some of these alloys possess the property of becoming soft and malleable when cooled suddenly while red-hot, by dipping into cold water, but of being hard and brittle when cooled slowly.

Name of Alloy.	Composition per cent. Copper.	Tin.
Bell-metal	78·0	25·0
Gun-metal	90·0	10·0
Speculum-metal	95·6	33·0
Bronze coinage	95·0	4·0 and 1 zinc.

(28) Speculum-metal is a very hard, brittle, steel-grey alloy, capable of receiving a very smooth and highly-polished surface.

ALLOYS OF COPPER AND ZINC.

(29) *Brass.*—Brass is the general name given to alloys of copper and zinc (ordinary brass consists of two of copper to one of zinc); by some writers also to alloys of copper and tin, now better known as *bronze*. Brass was known to the ancients, who prepared it from copper and calamine (§22), as they were unacquainted with the metal contained in calamine. We are said to have learned the fusing of copper with calamine from the Germans, and until a comparatively recent date brass, called calamine brass, was thus prepared in this country. Between 1780 and 1800, various patents were taken out for improving the manufacture of brass, by fusing copper and zinc direct instead of employing calamine. The calamine method, however, did not at once die out, as it was thought by some that calamine brass was better than that made direct.

In the manufacture of brass, the copper is first

melted, because of its high melting-point, and the zinc warmed, is then let down by tongs into the crucible containing the molten copper, plunged under its surface, and held there till melted. The mass is then stirred with a hot brass or iron rod, so as to mix the metals, great care being taken not to introduce any cold or damp matter. A little sulphate of sodium 'salt-cake', or carbonate of sodium 'soda-ash,' thrown into the crucible at the moment of pouring, assists in raising any impurities to the surface, which can then be skimmed off as the mass is poured. With proper management, the loss of zinc is not so great as might be expected, considering the comparatively low temperature at which it volatilises, and the relatively high temperature necessary to melt the copper.

(30) Brass is harder than copper, and therefore stands wear better; it is very malleable and ductile, may be rolled into thin sheets, shaped into vessels by 'spinning' (see § 33) stamping, or by the hammer, and may be drawn into fine wire. It is well adapted for casting, as it melts easily at a lower temperature than copper and is capable of receiving very delicate impressions from the mould. It is said to resist atmospheric influences better than copper, but when its surface is unprotected by lacquer, it rapidly tarnishes and becomes black. It has a pleasing color, takes a high polish, and is cheaper than copper.

(31) The malleability of brass varies with its composition, and the heat at which it is worked. The malleability is also affected in a very decided degree by the presence of various foreign metals in its composition, even though these are present in but minute quantity. Brass intended for door-plate engraving is improved by the presence of a little tin; or by the presence of a little

lead if to be used in the lathe or for casting. Brass for wire-drawing, however, must not contain lead; nor must brass intended for rolling contain antimony, which renders it brittle. Some kinds of brass are only malleable while cold, others only while hot, others are not malleable at all. A good example of the remarkable malleability of certain kinds is furnished by *Dutch Metal*, which contains a large proportion of copper, and which can be hammered into leaves of less than 1-57000 of an inch in thickness.

Though extremely tenacious, brass loses its tenacity in course of time by molecular change, especially if subject to vibration or continued tension. It is therefore unfitted for chains or for the suspension of weights. Chandelier chains have been known to lose their tenacity, become brittle, and break; and fine brass wire, which is of course brass in a state of tension, will, in time, become quite brittle, merely hanging in a coil.

(32) *Muntz' Metal* is a variety of brass consisting of about three parts of copper or two of zinc, with about one per cent. of lead. The alloy is yellow, and admits of being rolled at a red-heat. It is extensively applied for the sheathing of ships, as it is said to keep a cleaner surface than copper sheathing.

Hard Solders.—These are treated further on.

The number of alloys of copper and zinc is considerable, and there is great confusion in respect of their names and composition. The table on opposite page, showing the proportions of some alloys of copper and zinc, is an extract from a table by Dr. Percy.

(33) *Britannia Metal.*—We follow on with this alloy although not an alloy of copper and zinc alone. Britannia metal is highly malleable and one of the best of the substitutes for silver. It is composed of tin, an-

timony, copper, bismuth, and zinc, in various proportions, according to the purpose for which it is required. If the alloy is to be 'spun,' that is, worked into shape by specially formed tools whilst revolving in a lathe, a greater proportion of tin is used than when the alloy is only to be rolled. If it is to be cast, the proportion of tin is much less.

(34) *Alloys of Tin and Lead.*—Alloys of tin and lead furnish us with our soft solders, and are therefore of great practical value.

(35) *Pewter.*—The composition of pewter varies considerably. Common pewter consists of tin and lead alone; the best contains also small percentages of antimony, copper, and bismuth; varying indeed but little from Britannia metal.

SOLDERS.

(36) A solder is a metallic composition, by the fusion of which metals are united. The requirements of a good solder are twofold. (1) Its melting point must be below that of whatever metal is to be joined; (2) it must run easily when melted. It is comparatively easy (§25) to fulfil the first condition of a good solder. To fulfil the second requirement, one of the constituents of the solder must be either the same metal as that to be soldered, or a metal which will readily alloy with it, or which will readily coat its surface.

(37) Soiders are 'soft' or 'hard,' according to the temperature at which they melt. Hard solders fuse at a red heat. Soft solders are those which can be applied with a 'soldering iron,' that is to say, a 'copper bit,' or 'plumber's iron,' or with a mouth blowpipe; these solders melt below 300° C. Hard solders have a much higher fusing point, and require either a forge or a blast

blowpipe to apply them. Soldering with hard solders is termed 'brazing.'

(38) An important particular in the preparation of solders is that they should be well stirred before pouring, preferably with a piece of green wood (§ 21) and the surface of the molten metal exposed as little as possible to the air, so that 'dross' (oxide) shall not form on the surface. A few knobs of charcoal on the molten metal will to a very great extent prevent the formation of dross.

(39) Examining the soft solders, we see that plumber's solder melts at 227° C., that is to say, at a lower melting point than the metal (lead pipe), for soldering which it is used. Further, it is largely composed of lead. It thus fulfils both the requirements of a good solder. Tinman's solder melts at 160° C. It is used for soldering tin-plate, which, remember, is iron coated with tin. Tin melts at 230° C., a higher temperature than that of its solder, and tin is a constituent of the solder. Again the conditions of a good solder are fulfilled. Tinman's solder is also used for soft-soldering copper, because an alloy of lead and tin will readily coat copper, as also readily alloy with it.

SOLDERING METALS.

(40) Substances that 'flux' or aid the flow of metals when melting or melted are termed '*fluxes*.' The general subject of fluxes is outside our province; we are, however, specially interested in what we have designated '*soldering fluxes*' namely those fluxes that facilitate the flow of the solders and of the metals of which they are composed.

(41) Essentially this 'fluxing' consists in the prevention of the formation of oxide (§ 3) to which metals

TABLE OF SOLDERS.

	No.	Name.	Metals composing it, and their proportion.	Melting-point (Centigrade.)	Uses.
			Lead. Tin.		
Soft Solders.	1	Plumber's solder.....	2 1	227°	For joining lead-pipe.
	2	Coarse "	3 1	250°	
	3	Fine "	1 2	171°	Blowpipe or gas-fitter's solder; sometimes used by tinmen.
	4	" "	1 1½.....	168°	First-class tinman's-solder; used also for soldering zinc, and the 'metal' wheels, floats, &c., of wet gas-meters.
	5	Very fine "	1 3	180°	
	6	Very fusible "	1 1	160°	Ordinary tinman's solder.
	7	" " "	1 1 and 2 bismuth....	95°	Pewterer's solder.
			Copper. Zinc. Silver.		
Hard Solders.	1	Spelter, hardest.....	2 1 0	..	For ironwork, gun-metal, &c.
	2	" hard.....	1½ 1 0	..	For copper and iron.
	3	" soft	1 1 0	..	For ordinary brasswork.
	4	" finer	2 2 ¼	..	For finer kinds of brasswork.
	5	Silver solder, hardest.	1 0 4	..	Hardest, but makes very neat joints.
	6	" " hard ...	1 0 1	..	Makes a sound joint, and will not burn.
	7	" " soft	1 0 2		For general use.

are very prone when highly heated or molten. The black scale (§ 20) that forms on the surface of copper, for instance on copper 'bits,' when highly heated, is an oxide; also the scale that falls off red-hot iron when hammered (§ 14); and also the 'dross' that forms on the surface of molten lead or molten solder (§ 38).

(42) The employment of charcoal (carbon) for the purpose of preventing the formation of dross we have already alluded to in speaking of the preparation of solders. Sometimes a layer of it is spread over the surface of the molten metal to keep it from contact with the air; sometimes a layer of grease.

In their character of aiding the flow of metals, fluxes are further applied to the surface of the metals to be soldered, which they clean, as well as aiding the flow of the molten solder when that is applied.

(43) '*Spirits of Salts*' (hydrochloric of muriatic acid) when 'killed' is a most useful flux for soft solders, The 'killing' is done by dissolving zinc in the acid till gas is no longer given off, As the gas is most offensive, the dissolution of the zinc should be effected in the open air. This flux is not one to be used where rust would be serious; though there is very little danger of this, if, after soldering, the joint is wiped with a clean damp rag, and further cleaning and whiting.

(44) *Resin, or resin and oil* is a good flux for almost any kind of soft soldering. The surface to be soldered must, however, be well cleaned before applying the flux.

(45) '*Killed spirits*' (chemically, *chloride of zinc*) is specially useful for tin-plate soldering, because it assists in cleaning the edges to be joined; whereas if resin, or resin and oil, is used, the edge must, as stated, be cleaned previously.

No.	Composition per cent.		Specific Gravity.	Color.	Qualities, etc.
	Copper	Zinc.			
1	86·3	12·7	8·705	Reddish yellow	Not so good for rolling, wire-drawing, or hammering as common brass.
2	85·4	14·6	8·591	Yellowish red.	
3	83·02	16·98	8·415	Yellowish red	Behaves irreproachably under hammer, rolls, and in wire-drawing.
4	74·58	25·42	8·397	Pale yellow	Working qualities the same as those of common brass. It is said this alloy was puffed up in England, under the name of Mosaic Gold.
5	66·18	33·82	8·299	Full yellow	Works excellently under the hammer, rolls, and in wire-drawing.
6	52·0	48·0	8·229	Nearly gold yellow . .	Much to be recommended on account of its golden color. Well adapted for cast ware; after casting very flexible while still hot; hard to cut when cold. It is unsuitable for wire-drawing, hammering, or rolling.
7	32·85	67·15	8·283	Deep yellow	A tough alloy.
8	31·52	68·48	. .	Silver white	Too hard to file or turn.
9	30·3	69·7	. .	Silver white	Lustre nearly equal to speculum metal
10	29·17	70·83	. .	Silver white to silver grey.	

(46) Spirits of salts not killed is used for soldering zinc because it cleans the surface of the zinc; it acts indeed as chloride of zinc, for this is what it becomes on the application to the zinc, in fact the cleaning is the result of this action. The killed spirits, however, answers equally well as the strong acid if the zinc is bright and clean, so far as the experience of the writer has gone. The 'raw' (unkilled) spirits of salts is improved, as a flux for soldering zinc, by adding a small piece of soda to it.

(47) Powdered resin, or resin and oil, as a flux, possesses the great advantage over chloride of zinc, that there is no risk of rust afterwards. For this reason resin, or resin and oil, is much used in the manufacture of gas-meters. It is also used, or should be, for the bottoms and seams of oil bottles. The resin and oil flux can easily be wiped off joints immediately after soldering; it is for this reason better than dry resin which has to be scraped off. Even this trouble, however, can be got over if the hot copper bit is dipped in oil before application to the joint to be soldered.

(48) In 'tinning' a copper bit, that is, coating its point with solder before using it in soldering (a piece of manipulation of much importance as regards the easy working of the bit), the best thing to use is a lump of *sal-ammoniac*. In a small hollow made in the sal-ammoniac, the point of the bit, after having been filed smooth and bright, should be well rubbed, while hot, along with some solder; the point of the bit will then become coated with solder ('tinned'). For 'tinning' copper utensils, that is, coating them with tin, sal-ammoniac, both in powder and lump is largely used. Sal-ammoniac water is also used for cleaning copper bits; the hot bits being dipped into it prior to being used for

soldering. Killed spirits, however, act better. Sal-ammoniac and resin, mixed, is used as a flux for soldering 'sights' on gun-barrels.

(49) As a flux for lead soldering, plumbers use tallow ('touch'). For pewter, Gallipoli oil is the ordinary flux.

(50) For hard soldering, the flux is *borax*. This flux is also made use of in steel welding.

SEAMS OR JOINTS.

We illustrate herewith the more important seams or joints used in sheet metal work. The drawings are intended to aid in the intelligent comprehension of the formation of joints, and not as exact representations of them.

Lap Seam.—In No. 1 is shown how metal plates are arranged for a lap seam which is to be soldered.

Circular Lap Seam.—No. 11 shows how the edge of the bottom of a cylindrical article is bent up previous to soldering. It is evident that this seam is essentially No. 1 seam adapted to the fitting a bottom to a cylinder. Such bottom is called a 'snuffed on' or 'slipped on' bottom.

Countersunk Lap Seam.—This is represented in No. 2. It will be seen that the edge of one of the plates is bent down, so that the edge of the plate to be joined to it may lie in the part bent down, and that the two plates when joined may present an unbroken surface.

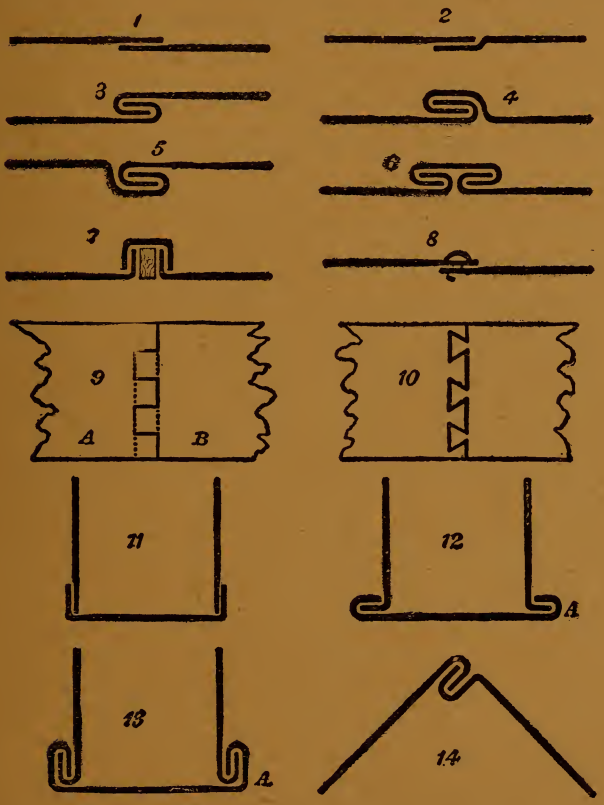
Riveted Lap Seam.—This is shown in No. 8. The amount of lap should not be less than three times the diameter of the rivet.

Folded Seam.—No. 3 shows how the edges of plates are prepared for folded seam.

Circular Folded Seams.—With a circular article the

folded seam is sometimes in the form of No. 12, which shows a 'paned down' bottom to a cylinder. This seam is essentially No. 13.

Another form of circular folded seam is shown in No. 13. It is really No. 12 seam turned up, so as to lie close against the cylinder (see reference letter A in



Nos. 12 and 13). A bottom thus fitted is called a 'knocked up' bottom. Here again comparison with No. 3 should be made.

Double Folded Seam.—This is shown in No. 6, and needs no explanation. It is used with thick plates,

where these when joined have to present to the eye an unbroken surface; as in the hot-plates of large steam-closets.

Grooved Seam.—This is represented in No. 4. It will be seen that the seam is the same as No. 3, but one plate is countersunk. In fact No. 3 shows the seam as prepared for countersinking ('grooving') with a 'groover.' Seam No. 6 is used where plates are too thick for grooving.

Countersunk Grooved Seam.—This seam (No. 5) is used when an unbroken surface is required on the outside of an article, for example, in toilet-cans, railway-carriage warmers. It is prepared as No. 3 and then countersunk the reverse way to No. 4.

Box Grooved Seam.—This seam, shown in No. 14, is used for joining plates in 'square work,' as for example where the ends and sides of a deed-box are joined together. It is essentially No. 3 seam.

Zinc-roofing Joint.—The arrangement for this joint is seen in No. 7. This joint admits of the expansion and contraction of the zinc sheets. The edges of two sheets, the wood 'roll,' and the 'roll cap' are shown. The zinc 'clip,' by which usually the sheets of zinc are held down, is not represented.

Brazing Joints.—A brazing joint for thin metal is shown in Fig. 9. The edge of plate A is cut to form laps as represented, and these laps are arranged alternately over and under the edge of plate B.

For thick metal the brazing joint is shown in Fig. 10. It is essentially the same thing as the 'dovetail' joint of the carpenter.

CHAPTER VIII.

MOULDINGS.

(1) The following chapter treats of mouldings. With these, the essential condition for the formation, with two pieces of moulding, of a joint at any angle, is that the section or end-shape of each piece at the "mitre" or junction shall be the same. This condition should always be borne in mind, and it is fulfilled when, in the plan of the joined pieces on the horizontal plane, the mitre-joint shows as a line bisecting the angle that the two pieces make with one another; for then, as a little consideration will show, there is the same section or cut on each piece. Thus, if this angle is a right angle, that is, if the two pieces of moulding meet "square,' the joint line makes an angle in plan of 45 degrees with the internal and external edges of each of the pieces; if the angle of meeting is of 120 degrees, as with six pieces of moulding forming a regular hexagon in plan, each joint line makes an angle of 60 degrees with the internal and external edges of either adjacent piece, and so on.

(2) In dealing for pattern-making purposes with the section or shape of a moulding (§ 3), it is convenient to draw it on two straight lines at right angles, the extremities falling one on either line, and the shape being arranged in respect of one of the lines just as the moulding itself is disposed to the surface to which it is applied; this line is thus part plan line—or part eleva-

tion line—of that surface. Looking to Fig. 1 (Problem I) the section or shape K I H E D C B A is drawn on the indefinite lines A K′, K′ K, at right angles, one extremity of the shape standing at a point A in A K′, and the other extremity at a point K in K′ K. The plane of the paper being the plane of the section, then, if A K′ represent the surface to which the moulding is applied, A K′ is the depth of the moulding, and K′ K its outstretch or span. If K′ K represent that surface, then K′ K is the depth of the moulding and K′ A its span. Thus, that plane of section of a moulding which gives its shape is a plane that contains the lines both of its depth and span.

(4) It is necessary to observe that when the section of a moulding or shape of it is spoken of, with no qualifying words, the section is supposed to be on the plane just referred to.

(5) In some of the figures that follow, with a view of helping the student, the space contained between the line of shape, and the lines of depth and span, is shaded, as in representing a solid moulding; our readers will however remember that only the shaded line is the moulding.

Problem I.

Given the shape and length of a piece of moulding to draw the pattern for it.

Fig. 1 is the shape of a piece of moulding drawn on the lines A K′, K′ and A L (Fig. 2) its length. Obviously the pattern for the piece of moulding will be a rectangle marked with certain lines upon which, with the given shape as a guide the rectangle has to be bent and formed, so as, at its end, to present that shape.

Draw (Fig. 3) any line X X, and from any point A in it draw A Y at right angles to X X. From A along

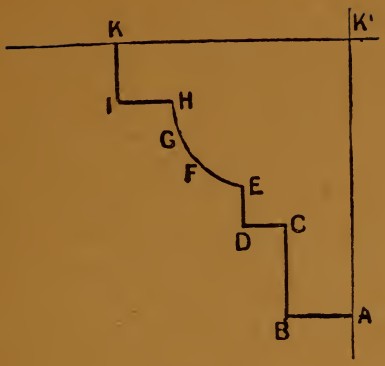


Fig. 1.

Fig. 2.

Fig. 3.

X X draw off A L equal to A L (Fig. 2), and from L draw L Y′ parallel to A Y. On A Y successively distances A B, B C, C D, D E, E F, F G, G H, H I, and I K, equal respectively to A B, B C, C D, D E, E F, F G, G H (F find G are any points in E H, the curved portion of the shape), H I, and I K of Fig. 1. From the points B, C, D, E, F, G, H, I, and K draw lines parallel to A L and terminating in L Y′ in the points B′, C′, D′, E′, F′, G′, H′, I′ and K′ respectively; A K K′ L will be the rectangle pattern required, and the several lines parallel to A L will be the lines by which the pattern is to be bent up and formed to the given shape.

In setting off on A Y the distances E F, F G, and G H, the mechanic must bear in mind that the distances he sets off are chords and not arcs, and that it may be necessary to make allowance for this.

Problem II.

The shape of a moulding being given, to draw the shape at any angle of section of the moulding, and the pattern for a piece of the moulding cut at that angle. Also, conversely, the section of a moulding at any angle being given to draw the shape of the moulding.

The cases of this problem that usually occur in practice are where the plane of section contains the line of span of the moulding, but not the line of its depth, or contains the line of its depth, but not that of its span, and one particular example of where that plane contains neither line of depth nor line of span.

(6) Here are seemingly two cases, they are however one and the same, as will be seen from this. Let *h g′ f′ e′ d′ c′ b′ a′* (Fig. 4), drawn on the lines *a h*, *a* N, be the given shape of the moulding, one extremity

of it falling on the line *a h* at *h*, and the other at *a'* on *a* N. If of the lines *a h*, *a a'*, the line *a h* represents in plan the surface to which the moulding applies (§ 3),

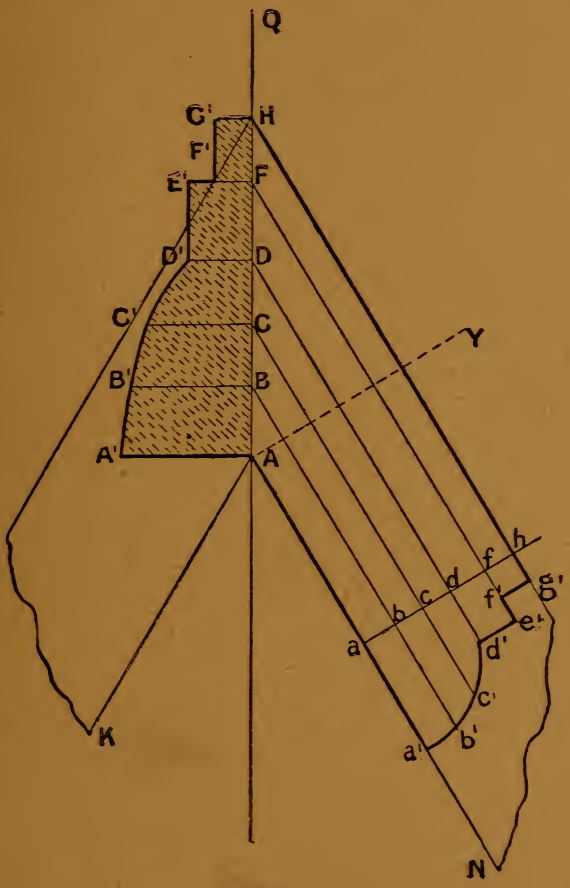


Fig. 4.

then *a h* is the depth of the moulding, and *a a'* its span. If *a a'* represents that plan line, then *a a'* is the depth of the moulding, and *a h* is its span. Thus the lines *a h*, *a a'*, will be respectively depth and

span, or span and depth, according to which of them represents the surface for the moulding, and the plane of section will be described correspondingly. The working drawing for a section at an angle is that which shows the angle.

(7) Producing the lines *a' a* and *g' h* indefinitely, lines which are perpendicular to *a h* by construction, and by the given nature of the moulding *a h* H A will represent in plan, a piece of the moulding *h g' f' e' d' c' b' a'*. A plane of section of the moulding at any angle N A Q is represented by the line A Q cutting the indefinite lines *a* A and *h* H in the points A and H. This plane is perpendicular to the plane of the plan, but does not contain both its lines of span and depth. The plan line of a plane passing through the point A, and containing the lines both of span and depth, would be the line A Y.

(8) To get the shape of the moulding on the plane of A Q. Produce the line *e' f'* (also perpendicular to *a h* by the given nature of the moulding), cutting *a h* and A Q in *f* and F respectively, and from the point *d'* draw a line parallel to the line just drawn, cutting *a h* and A Q in *d* and D respectively. In *d' a'*, the curved part of the moulding, take any points *c'*, *b'*, and from these points draw lines *c'* C, and *b'* B, parallel to *a'* A, cutting *a h* in *c* and *b*, and A Q in C and B, respectively. From A, B, C, D, F, and H, draw lines perpendicular to A H, and A A', B B', C C', D D', F E', F F', and H G' equal respectively to *a a'*, *b b'*, *c c'*, *d d'*, *f e'*, *f f'*, and *h g'*. Join G' F' and E' D' by straight lines, and D' C' B' A' by an unbroken curved line; the line H G' F' E' D' C' B' A' will be shape required of the moulding on the plane of section A Q. This shape is often useful as a template.

To draw the pattern for the shape. Draw (Fig. 5) any line *a h*, and from a point *a* in it set off distances *a b*, *b c*, *c d*, *d e*, *e f*, *f g*, and *g h*, respectively equal to the distances *a' b'*, *b' c'*, *c' d'*, *d' e'*, *e' f'*, *f' g'*, and *g' h* (Fig. 4). Through *a* draw a line perpendicular to *a h*; make *a* A equal to *a* A (Fig. 4), and from A draw a line parallel to *a h* terminating at a point Y in an indefinite line drawn from *h* perpendicular to *a h*. Through *b*, *c*, *d*, *e*, *f*, and *g*, draw indefinite lines *b* B, *c* C, *d* D, *e* E, *f* F, and *g* G perpendicular to *a h* and cutting the line A Y, then the rectangle *a* A Y *h*, with its guide lines between

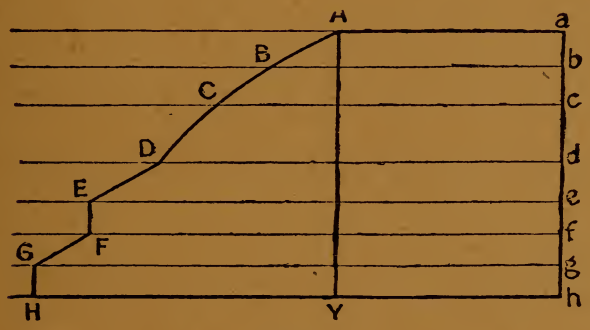


Fig. 5.

a A and *h* Y parallel to those lines, is the pattern of the length of moulding (see last problem) *a* A Y *h* (Fig. 4). On *b* B, *c* C, and *d* D, set off distances *b* B, *c* C, and *d* D, equal respectively to *b* B, *c* C, and *d* D (Fig. 4); on *e* E and *f* F distances *e* E and *f* F each equal to *f* F (Fig. 4) (the points *e'* and *f'* coinciding with each other in plan of the moulding), and on *g* G, and *h* H distances *g* G and *h* H, each equal to *h* G (Fig. 4) (the points *g'* and *h'* coinciding with each other in plan of the moulding). Through the points A, B, C, D, draw an unbroken curved line, and join D E, E F, F G, and G H by

straight lines. Then A B C D E F G H will be the pattern required.

(9) The pattern for the piece of moulding cut at the angle N A Q (Fig. 4) is also found; it is *a* A H *h* of (Fig. 4); which pattern, if bent up to the lines *d* D, *e* E, *f* F, and *g* G, and rounded up between the lines *a* A and *d* D, will form the moulding required.

(10) In respect to the curve A B C D the caution given in the last problem should be borne in mind. In choosing division points on curves of mouldings, from which, by means of lines to find points for any required section, the workman must be guided by the length and style of a curve. Lines from angular points of a shape such as *h*, *g'*, *f'*, *e'*, and *d'*, must always be drawn, as these not only give the angular points in the required section, but are lines on which the pattern of a piece of moulding must be angled up to form the moulding.

The pattern piece of a moulding may be made of any desired length. Length is obtained by simply producing the lines A *a*, B *b*, C *c*, D *d*, E *e*, F *f*, G *g*, and H *h*. If length is not required, but the mitre-line end only of the pattern, this could be found by taking measurements from the line A Y (Fig. 4) instead of *a h*; the pattern thus obtained would be A B C D E F G H Y (Fig. 5).

(11) What has been done in this first Case should be noted by the student. The angular points of the moulding, and other chosen points are projected on to one of the lines, *a h* (Fig. 11) on which the shape is drawn, and thence on to the line in which the moulding is cut. The plane of the cut, whatever its angle, being perpendicular to the surface to which the moulding is applied, span lengths are not affected, but remain unaltered. Depth lengths, however, such as *g' f'*, *e' d'*

(Fig, 4), and the perpendicular length from *d'* to the line *a a'* are altered, and the true lengths that these become in the shape of the moulding in the plane of the cut appears in the line H A as H F, F D, and D A respectively.

CONVERSE PROBLEM—*The section of a moulding at any angle being given, to draw the shape of the moulding.*

Let A D'E'F'G'H (Fig. 4) be section of a moulding N A H *h* cut at the angle NAQ. Divide A'D' into any number of equal parts, here three, in the points B' and C', and from the points A', B', C', D', and E' draw lines perpendicular to A Q, cutting that line in the points A, B, C, D, and F. The point F' is, by the nature of the section, a point in E' F; and the line G' H is already perpendicular to A Q. From any point *a* in N A draw *a h* perpendicular to N A, cutting H *h* in *h*, and from B, C, D, and F draw lines parallel to N A, cutting *a h* in *b*, *c*, *d* and *f*. From *a* on A N set off *a a'* equal A A'; from *b*, *c* and *d* set off *b b'*, *c c'*, and *d d'* respectively equal to B B', C C', and D D'; from *f* set off *f f'* and *f e'* respectively equal to F F' and F E'; and from *h* set off *h g* equal to H G'. Join *a'* to *d'*, through *b'* and *c'*, by an unbroken curved line, and join *d' e'* and *f' g'*. Then *a' b' c' d' e' f' g' h* will be the shape required.

PROBLEM III.

The shape of a moulding being given, to draw the pattern for joining two pieces of it at any angle.

Let *h g' e' d' a'* (Fig. 4), drawn on the lines *a h*, *a a'*, be the given shape of the moulding, and K A N the angle at which the two pieces of it are to meet. Bisect the angle K A N, then A Q is the direction of the mitre line, and the two pieces are represented by

K A H and *a* A H *h*. As there is the same section or cut on each piece, the problem now becomes that of drawing the pattern for the piece of moulding, say *a* A H *h*, cut at the angle A H *h*. This is done by means of the problem preceding.

(12) A method used in practice for finding the line A Q, that is for bisecting the angle K A N, is to set off from A equal distances along A K and A N, to join the points thus found by a straight line, and then by means of a square applied to this line to draw a line perpendicular to (square with it) and passing through the point A. This is a perfectly correct procedure.

Problem IV.

To draw the pattern for an aquarium (or other) base formed of a moulding of one and the same design.

Let A′B′C′D′ (Fig. 7) be the plan of the inside edge of the aquarium (or other) base, and E F (Fig. 6), the shape of the moulding, drawn on the lines G F and G E; G E representing the surface on which the aquarium stands. Bisect each of the angles of the plan by the lines A′A, B′B, C′C, D′D. Through either of the angular points, here D′, draw a line perpendicular to A′D′; and on it set off D *f*′ equal to G E (Fig. 6). Through *f*′ draw a line parallel to A′D′, and intersecting A′A and D′D in A and D respectively. Through D and A draw lines parallel to D′ C′, and intersecting C′C and B′B in C and B, and join C B. Then A B C D will be the plan of the outer edge of the aquarium stand or other base, and A′A, B′B, C′C, and D′D, the plans of the mitre joints (§ 6).

If the plans of the outside edge of the aquarium (or other) base be given or first drawn, as A B C D, the

plan of the inside edge will be thus found. Bisect, first of all, the angles A, B, C and D. Next draw a line (not shown in the Fig.) perpendicular to one of the edges, say A D, on its inner side, from any point in it (the line f' D′ is such a line, if f' be regarded as not a particular point in A D but as any point in it); on this line set off a distance equal to E G (Fig. 6), and through the extreme point of this draw a line parallel to A D, intersecting the bisecting lines of the angles at D and A in the points D′ and A′. Through D′ and A′ draw lines parallel to D C, intersecting the bisecting lines of the angles C and B in the points C′ and B′ and join C′ B′. Then A′ B′ C′ D′ is the plan of the inner edge of the stand.

Fig. 6.

The problem is now essentially completed, and is simply that of drawing the pattern for the E F (Fig. 6) moulding on either mitre plane, which is done by Problem III. It will be a help to the student, however, to work the problem in detail right through. We already have the line D′ f' if the inner edge was first drawn; if the outer edge was first drawn, let fall now from D′ a line perpendicular to A D, meeting this line in f; then D′ f, being parallel to the line, not shown, drawn perpendicular to A D on which the distance E G was set off, will be itself equal to E G. Now on D′ f', D′ A′,

draw f' d'' the required shape of the moulding, disposed towards D′ f' as to the surface on which the moulding stands; and divide it into any number of parts, equal or unequal (see § 10). The division is here into six equal parts, in the points a', b', c', d', and e', through which points draw lines 1 to 1, 2 to 2, 3 to 3, 4 to 4, and 5 to 5

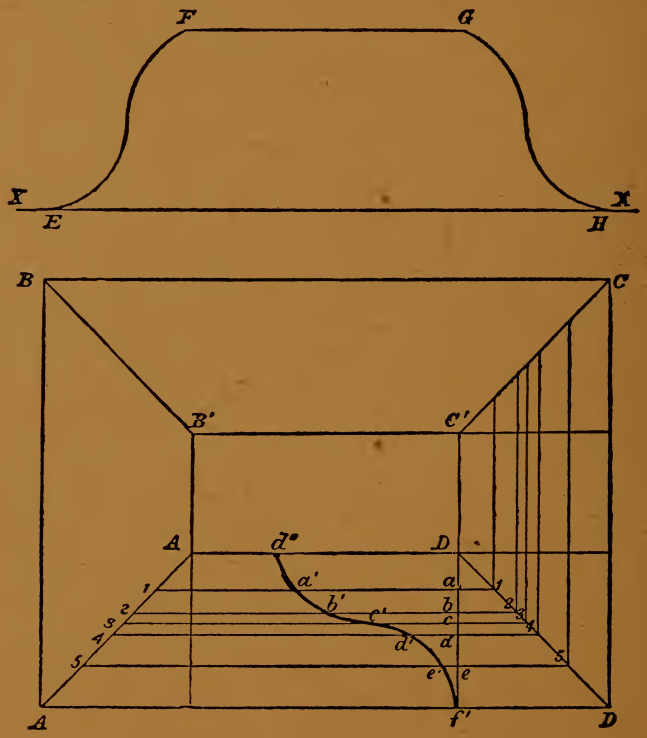


Fig. 7.

parallel to A D, and terminating in A′ A and D′ D, and from points 1, 2, 3, 4, and 5, in the line D′ D draw lines parallel to D C and terminating in C′ C.

To draw the pattern for the A′ D′ A D portion of the base. Draw (Fig. 8) any line K L; and from any

point D′ in it set off D′ *a*, *a b*, *b c*, *c d*, *d e*, and *e f* equal respectively to the distances *d′′ a′*, *a′ b′*, *b′ c′*, *c′ d′*, *d′ e′*, and *e′ f′* around the curve *d′′ c′ f′* (Fig. 7); and through the points D′, *a*, *b*, *c*, *d*, *e*, and *f′* draw lines perpendicular to K L. Make *a* 1 equal to *a* 1 (Fig. 7), and *b* 2, *c* 3, *d* 4, *e* 5, and *f′* D respectively equal to *b* 2, *c* 3, *d* 4, *e* 5, and *f′* D (Fig. 7); and through the points D′, 1, 2, 3, 4, 5, and D draw an unbroken

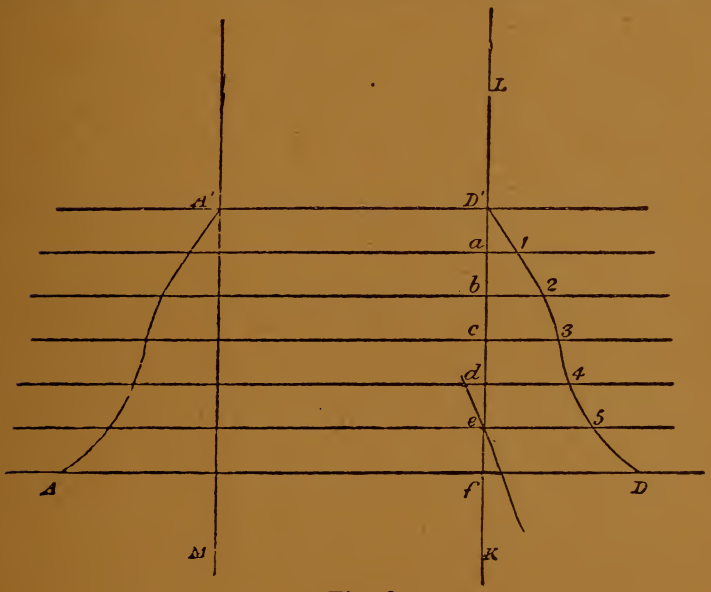


Fig. 8.

curved line. Now from D′ set off D′ A′ equal to D′ A′ (Fig. 7), and through A′ draw A′ M parallel to K L. From the points in A′ M, where the lines *a*, *b*, *c*, *d*, *e*, and *f′* cut A′ M, set off distances to the left of A′ M corresponding to the distances *a* 1, *b* 2, *c* 3, *d* 4, *e* 5, and *f′* D to the right of the line K L, and through the points there found draw an unbroken curved line. Then A′ D′ A D will be the pattern required.

To draw the pattern for the D′ C′ D C (Fig. 7) portion of the base. It will be at once seen from the plan that this differs from the A′ D′ A D portion, only in that the distance D′ C′ is less than the distance A′ D′; and thus that, if the lines A′ M and L K (Fig. 8) are brought closer together, so that A′ D′ is equal to D′ C′ (Fig. 7), the pattern so obtained will be the pattern required..

Problem V.

To draw the pattern for an aquarium (or other) base formed of mouldings not of one and the same design.

The problem now before us is that of fitting to a given aquarium or other body, which has to stand in a given position, a position, that is to say, of which the dimensions are fixed, a base made up of mouldings. In the last problem there are no restrictions as to the dimensions of the base.

(13) Let A′ B′ C′ D′ (Fig. 9) be the plan of the aquarium or other body to which a moulding base has to be fitted, and A B C D the plan of the position the body has to stand in. Join A′ A, B′ B, C′ C, and D′ D; these lines last drawn will be the plans of the mitre joints (§ 6). Looking at the plan, it is at once seen that the pieces of moulding on the B′ A′ and C′ D′ sides of the body, though equal to each other, are not of the same dimensions as the pieces, also equal to each other, on the B′ C′, and A′ D′ sides. An imperative condition of two pieces of moulding properly joining is that the sections of the pieces shall be the same on the mitre-plane (§ 1). That is to say, that here, for the pieces A′ D′ D A, C′ D′ D C to properly join notwithstanding the difference of their di-

mensions, their sections on the mitre plane of D′ D must be the same. When two pieces to be joined are of one and the same design, this condition of same section on the mitre-plane is fulfilled when the mitre line bisects in plan the angle that the pieces of moulding, as joined, make with one another (§ 1). That condition has now to be fulfilled when, the two pieces being unequal in dimensions, the mitre does *not* in plan

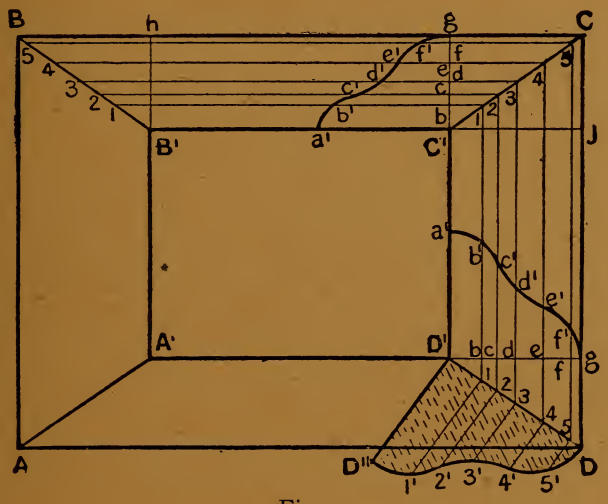


Fig. 9.

bisect the angle made with each other by the pieces; the line D′ D, for example, does not bisect the angle A′ D′ C′.

The shape for one of the mouldings may be given or chosen; let it be, say, that for the moulding piece D′C′ C D, or the piece B′A′ A B, which is equal to it; and let that shape be *g e′ c′ a′*, drawn on the lines D′*g* (a continuation of the line A′D′), and D′*a′* part of D′ C′). Regarding D′*g* as the line of span of the moulding, D′*a′* is the line of its depth, that is, of the distance

the moulding reaches up on the side of the aquarium or other body. The depth of all four pieces of moulding round the body is the same; it is not affected by the want of correspondence between the plan A′B′C′D′ and the plan A B C D. From C′ on C′B′ set off this depth, C′*a*′, equal to D′*a*′ and draw C′*g* perpendicular to C′B′ and meeting the plan line B C of the outer edge of the piece of moulding B′C′ C B in a point *g*. The line C′*g* then is the span of this moulding, and we shall now be able to draw on the lines C′*g*, C′*a*, the shape for it.

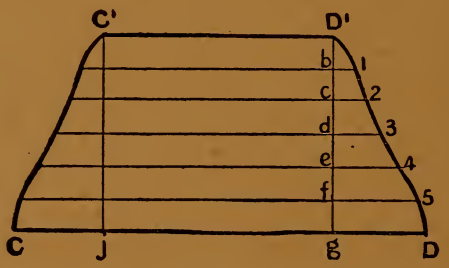


Fig. 10.

Divide *g e*′*c*′*a*′, the chosen shape for the moulding D′C′ C D, into any number of parts, here six, equal or unequal, in the points *b*′, *c*′, *d*′, *e*′, *f*′. Through these points draw lines parallel to C D, terminating in the mitre plan, lines C′C and D′D, and cutting D′*g* in *b*, *c*, *d*, *e*, and *f*; the drawn lines being the lines 1 to 1, 2 to 2, 3 to 3, 4 to 4, and 5 to 5. From the points 1, 2, 3, 4, and 5 on the line C′C draw lines parallel to B C, terminating B′B, and cutting C′*g* in *b*, *c*, *d*, *e*, and *f*. From these last points *b*, *c*, *d*, *e*, and *f*, set off distances *b b*′, *c c*′, *d d*′, *e e*′, and *f f*′, respectively equal to the distances of same letters from the line D′*g*, and through the points *a*′ (on C′B′), *b*′, *c*′, *d*′, *e*′, *f*′, and

g on C B draw an unbroken curved line; this line will be the shape for the moulding B′C′ C B.

Having the shapes of each of the mouldings, to draw the patterns for the pieces. First that for the D′C′C D pieces. Draw (Fig. 10) any line D′*g*, and from the point D′ set off distances D′*b*, *b c*, *c d*, *d e*, *e f*, and *f g*, equal respectively to the distances *a′b′*, *b′c′*, *c′d′*, *d′e′*, *e′f′*, and *f′g′* of the shape drawn on the lines D′*g*, D′*a* (Fig. 9) and through the points D′, *b*, *c*, *d*, *e*, *f*, and *g* draw lines perpendicular to D′*g*. Make *g* D equal to *g* D (Fig. 9), and make *f* 5, *e* 4, *d* 3, *c* 2, *b* 1 respectively equal to *f* 5, *e* 4, *d* 3, *c* 2, and *b* 1 from the line D′*g* (Fig.

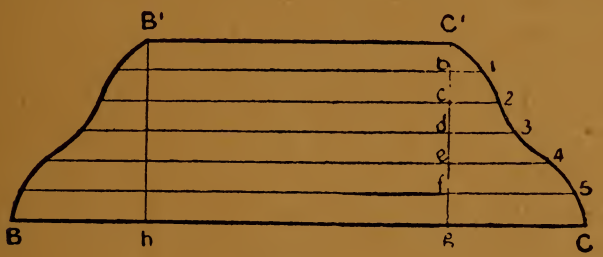


Fig. 11.

9); and from the point D′ through the points 1, 2, 3, 4, 5 to D draw an unbroken curved line. Now make *g j* equal to *g j*, (Fig. 9) and through *j* draw *j* C′ parallel to *g* D′. Set off *j* C′ equal to *g* D′ and then obtain points for and draw the curve C′C exactly as with the curve D′ 3 D, the two curves being alike. The pattern required will be C′D′D C.

To draw the pattern for the B′ C′ C B (Fig. 9) piece of moulding. Draw (Fig. 11) any line C′ *g*, and from the point C′ set off distances C′ *b*, *b c*, *c d*, *d e*, *e f*, and *f g*, equal respectively to the distances *a′ b′*, *b′ c′*, *c′ d′*, *d′ e′ f*, and *f′ g* of the shape drawn on the lines C′ *g*, C′ *a′* (Fig. 9), and from the points C′ *b*, *c*,

d, *e*, *f*, and *g* draw lines perpendicular to C′ *g*. Make *g* C equal to *g* C (Fig. 9) and make *f* 5, *e* 4, *d* 3, *c* 2, *b* 1 respectively equal to *f* 5, *e* 4, *d* 3, *c* 2, and *b* 1 from the line C′ *g* (Fig. 9); and from the point C′ through the points 1, 2, 3, 4, 5, to C draw an unbroken curved line. Now make *g h* equal to *g h* (Fig. 9), and through *h* draw *h* B′ parallel to C′ *g*. Set off *h* B equal to *g* C, and then obtain points for and draw the curve B′ B exactly as with the curve C′ 3 C; or copy the curve B′ B from the curve C′ 3 C, the two curve lines being alike. The pattern B′ C′ C B will be the pattern required.

The section or shape of either piece of moulding at the mitre plane is obtained as in Problem II, by drawing (Fig. 9) through the points D′, and 1, 2, 3, 4, 5 on the line D′ D, lines perpendicular to that line, and making D′ D″, 11′, 22′, 33′, 44′, and 55′, equal respectively to D′ *a*′, *b b*′, *c c*′, *d d*′, *e e*′, and *f f*′, and drawing from the point D″ through the extremities of these lines 11′, 22′, 33′, 44′, and 55′ to D an unbroken curved line. This section, however, is not needed for the problem.

Problem VI.

To draw the pattern for an inclined (raking) moulding, to mitre or join with a given horizontal moulding.

(14) This is the case closely allied to Problem II, being that of section of a moulding by a mitre plane which contains neither the line of depth of the moulding, nor the line of its span. It is easy to work because the mitre plane, so far as the given horizontal moulding is concerned, contains both of those lines. The case is not one, the student must notice, of joining two pieces of moulding *of the same shape* at any angle, one

of the pieces being inclined, but of so fitting to one shape of moulding a moulding *of another shape* that the plane of their junction shall contain the line of intersection of the two surfaces to which the mouldings are to apply. As a typical instance of the problem, sup-

Fig. 12.

pose the mouldings to be gutters, fitting say on a dormer window, or some part of a roof where one gutter is inclined and the other horizontal. The walls or surfaces (see Fig. 12) to which the mouldings fit are in this instance assumed to be perpendicular to each other, they may however be at any angle; this does not affect

the work of the problem. The plane of junction of the mouldings, however, *must contain the line of junction of the surfaces of the walls.*

Let f', e', d', c', b', a (Fig. 13) drawn on the lines A′ f', A′ a be the given shape of the horizontal moulding, the lines A′ a being part of elevation line of the surface to which the horizontal moulding applies; it may in fact be regarded as representing the line of junction of the two flat faces or surfaces of the walls to which the mouldings are to fit. The shape given is not chosen as a good one for a gutter only, but rather as a useful shape to illustrate principles. Hence also the term mouldings is employed instead of gutters, all gutters being mouldings (§ 5). Perpendicular to A′ a draw any line X X, produce A′ a indefinitely, as a N A, and from any point A′ in the produced line draw A K at an angle in plan equal to that at which the two pieces of moulding are to meet, now a square or right angle as above stated. Bisect the angle K A N by a line A Q, through f' draw f' M F perpendicular to X X, and intersecting A Q in F, and let M be the point in f' F in which a line from any point N in A′ A and perpendicular to it cuts f' F, and through F draw a line parallel to A K. Next choose division points in the curve d' a as most convenient (§ 10), the points here taken being c' and b'; from the-points b' c', and d' draw lines, each perpendicular to X X, to meet the line A Q, the lines namely b' B, c' C, d' D, and through B, C, and D draw lines parallel to K A. Then N M F A will be the plan of the horizontal moulding, and F K A that of the inclined moulding, and A F the plan of the mitre joint (§ 6). To draw the elevation of the inclined or raking moulding. From A′ draw A′ P at an angle to X X equal to the inclination of the

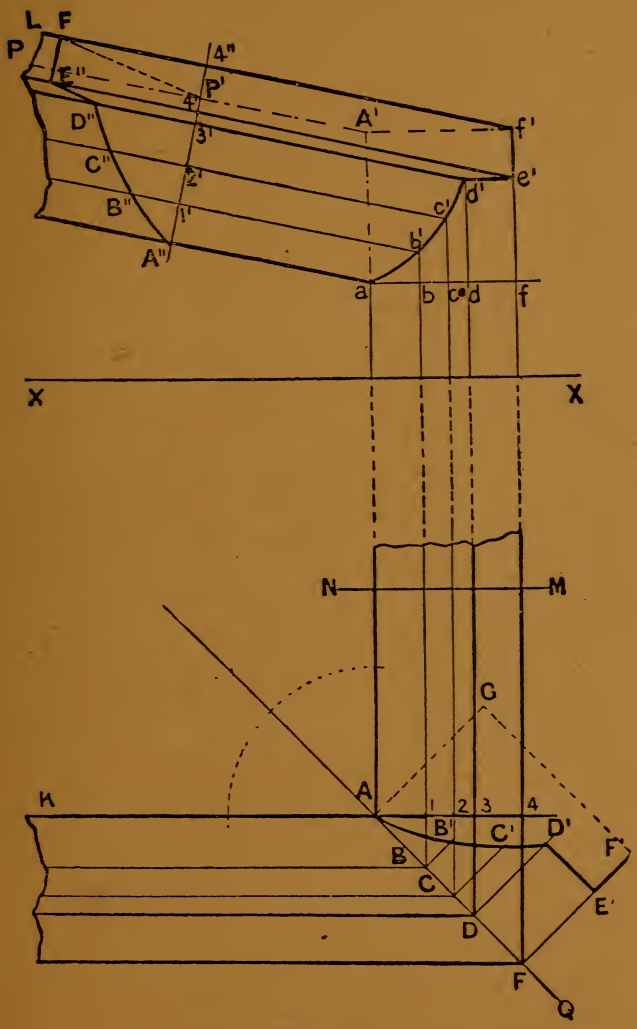


Fig. 13.

moulding, and from the points *f*, *e'*, and *d'* (§ 10), *c'*, *b'*, and *a'*, draw lines parallel to A' P, the *f* L *a* (L being a point in the line drawn from *f'*) is the elevation required.

To draw the shape of the raking moulding. From any point A'' in the line from *a* parallel to A' P draw a line perpendicular to *a* A'', meeting *f'* L in 4'' and cutting the lines drawn parallel to A' P from *e'*, *d'*, *c'*, and *b'* in the points respectively 4', 3', 2'. and 1', and continue the line K A to cut the lines *b'* B, *c'* C, *d'* D, and *f'* F in the points respectively 1, 2, 3, and 4. As the inclination of the moulding does not affect span dimensions, set off 1' B'' equal to 1 B, 2' C'' equal to 2 C, 3' D'' equal to 3 D, and 4' E'', 4'' F'' each equal to 4 F, the points *f'* and *e'* coinciding with each other, in the point F, in plan. Joining the points F'', E'', D'', C'', B'', A'' as shown, gives the shape for the inclined moulding, the shape that will mitre accurately in mitre plan A Q with the horizontal moulding.

To draw the pattern for the horizontal moulding N M F A. This is done by Problem III; in detail it is as follows:—Draw (Fig. 14) any line A *f'*, and from A set off distances A *b' b' c'*, *c' d'*, *d' e'*, and *e' f'* respectively equal to *a b'*, *b' c'*, *c' d'*, *d' e'*, and *e' f'* (Fig. 13), and through the points A, *b'*, *c'*, *d'*, *e'*, and *f'*, draw lines perpendicular to A *f'*. Make *f'* F, and *e'* E each equal to 4 F (Fig. 13), and *d'* D, *c'* C, *b'* B, equal respectively to 3 D, 2 C, and 1 B (Fig. 13). From A through the points B, C, and D draw an unbroken curved line, and join D E, E F. Then A B C D E F is the pattern required. The line N M corresponding to the line N M from any point N in A A' (Fig. 13) is drawn to indicate that the moulding may be of any length.

To draw the pattern for the inclined moulding F K A. Draw (Fig. 15) any line A″ 4,″ and from A″ set off A″ 1′, 1′ 2′, 2′ 3′, 3′ 4′, 4′ 4″ equal respectively to A″ B″, B″ C″, C″ D″, D″ E″, E″ F″, (Fig. 13), and through the points A″, 1′, 2′, 3′, 4′, and 4″, draw lines

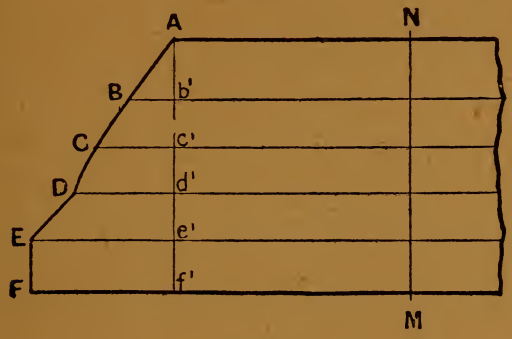


Fig. 14.

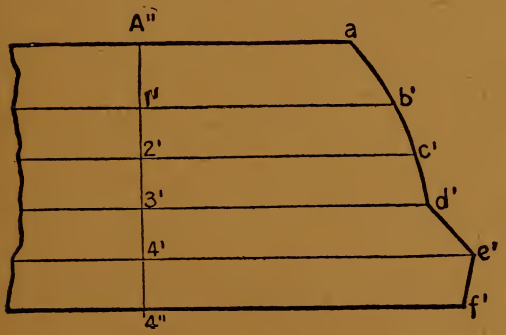


Fig. 15.

perpendicular to A″ 4″. Make A′ *a* equal to A″*a* (Fig. 13), and 1′ *b′*, 2′ *c′*, 3′ *d′*, 4′ *e′*, and 4″ *f′* respectively equal to 1′ *b′*, 2′ *c′*, 3′ *d′*, 4′ *e*, and 4″ *f′* (Fig. 13). Through the *a*, *b′*, *c′*, *d′*, draw an unbroken curved line, and join *d′ e′*, *e′ f′*; then *a b′ c′ d′ e′ f′* is the pattern required.

In the instance where the mouldings form a gutter a straight piece equal in depth to *a* A′ (Fig. 13) is necessary, with the horizontal moulding, to form a back to the gutter to fit against the wall (see Fig. 12). To the raking gutter also a back piece is required (see Fig. 12). The "wall-line," against which the top of the gutter would have to fit, is A′ P. The straight piece for the back would therefore be equal in depth to P′ A″ (Fig. 13), P′ being the point of intersection of A′ P with A″ 4″. The highest point at the back of the gutter is P′, the highest point in front is F″; the line F″ P′ is drawn to make this clear; and the workman in drawing the pattern must be careful not to use the line A′ P except as it has been used in the working of the problem.

Although not needed it will be useful to show how to obtain the mitre section of the mouldings at A F (Fig. 13). Draw through point *a* a line *a f* perpendicular to A′ *a*, cutting *b′* B, *c′* C, *d′* D, and *e′* F in the points *b*, *c*, *d*, and *f*. Through A, B, C, D, and F draw lines perpendicular to A F, and set off distances F F′, F E′, D D′, C C′, B B′, equal respectively to *f f′*, *f e′*, *d d′*, *c c′*, and *b b′*. Join F′ E′, E′ D′, and from D′ through C′ and B′ to A draw an unbroken curve; the section sought is F′ E′ D′ C′ B′ A′. The lines A G and G F′ represent the lines of depth and span of the horizontal moulding on the plane of junction of the walls or surfaces to which the gutter fixes.

Problem VII.

To draw the pattern for a lobster-back cowl.

Draw an indefinite line A O (Fig. 16), and from any point O in it draw a perpendicular O T. With O as

centre and radius equal to the diameter of cowl required, describe an arc A A′ T, cutting O T in T. Produce O T downwards, and make O Q equal to the depth of the rim required; through Q draw Q P, parallel to A O, and from A draw A P perpendicular to A O and cutting Q P in P; A O Q P is the elevation of the rim. To draw the hood T S R O, draw T S perpendicular to

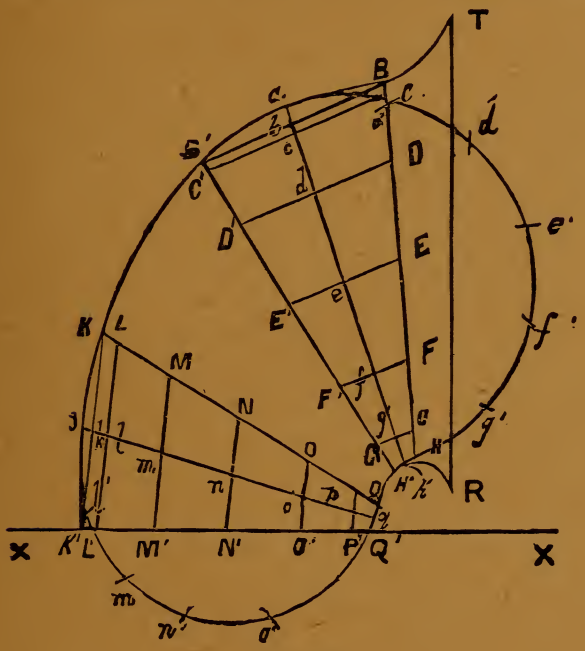


Fig. 16.

O T, make T S and O R of the required dimensions for the hood, and join S R. This completes the elevation P A′ S R O Q of the cowl. Now divide the arc A T into the same number of equal parts that the shell of the lobster-back is to have segments. Here we take the number of segments as three; A′ and G are the points of division of the arc. Joining these points to

O we have in G O T, A′ O G, and A O A′ the elevations of the segments of the shell.

To draw the pattern for the segments.

On either of the lines A O, A′ O, G O, T O describe a semi-circle, it is here described on A O, and divide it

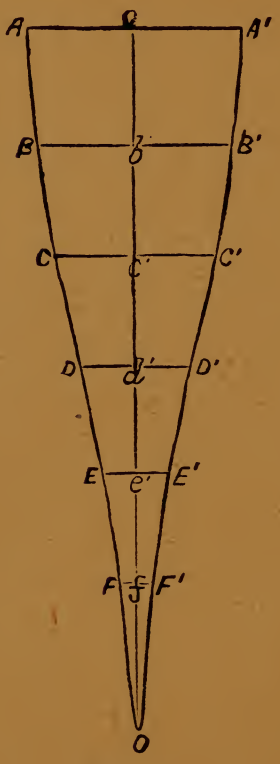


Fig. 17.

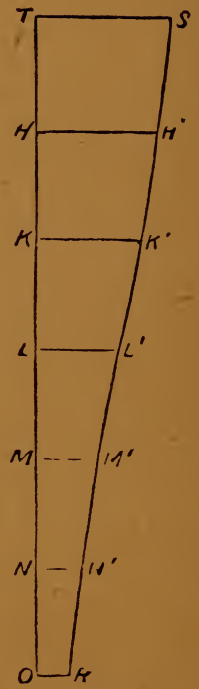


Fig. 18.

into any convenient number of equal parts, here six, in the points *b*, *c*, *d*, *e*, and *f*. Through *b*, *c*, *d*, *e*, and *f* draw lines perpendicular to A O, and cutting it in points B, C, D, E, and F respectively. With O as centre and radii O B, O C, O D, O E, and O F success-

ively, describe arcs B B′ H, C C′ K′, D D′ L, E E′ M, and F F′ N, cutting A′ G in the points B′, C′, D′, E′, and F′ respectively, and T O in the points H, K, L, M, and N respectively. We now find the pattern for the segment A O A′; the pattern for that segment, the segments being all equal, will be the pattern for all.

Bisect the arc A A′ in *k* and join *k* O. Join A A′, B B′, C C′, D D′, E E′, and F F by straight lines, cutting *k* O in points *a′*, *b′*, *c′*, *d′*, *e′*, and *f′*, respectively. Next draw an indefinite line *a′* O (Fig. 17), and on it set off *a′ b′*, *b′ c′*, *c′ d′*, *d′ e′*, *e′ f′*, and *f′* O, each equal to A *b* (Fig. 1), one of the equal parts into which the semicircle A *d* O is divided, and through each of the points *a′*, *b′*, *c′*, *d′*, *e′*, and *f′*, draw lines perpendicular to *a′* O. Make *a′* A′, *b′* B′, *c′* C′, *d′* D′, *e′* E′, and *f′* F′ respectively equal to *a′* A′, *b′* B′, *c′* C′, *d′* D′, *e′* E′, and *f′* F′ (Fig. 16); also make *a′* A, *b′* B, *c′* C, *d′* D, *e′* E′ and *f′* F respectively equal to *a′* A′, *b′* B′, *c′* C′, *d′* D, *e′* E, and *f′* F (Fig. 16). Join A, B, C, D, E, F, and O, and also A′, B′, C′, D′, E′, F′, and O by unbroken curved lines, then A O A will be half the pattern required, which can be completed by drawing A A′ a figure exactly the same as A O A′.

To draw the pattern for the hood T S R O.

Draw (Fig. 18) an indefinite line T O, and on it set off T H, H K, K L, L, M, M N, and N O, each equal to A *b* (Fig. 16), one of the equal parts of semi-circle A *d* O. Through each of the points T, H, K, L, M, N, and O draw lines perpendicular to T O; and make T S, H H′, K K′, L D′, M M′, N N′ and O R respectively equal to T S, H H′, K K′, L L′, M M′, N N′, and O R (Fig. 16). Join S, H′, K′, L′, M′, N′, and R by an unbroken curved line; T S R O will be the pattern for one-half of the hood; duplicating this on the line T S will complete the pattern.

If closer approximation is necessary the lines *a'* O (Fig. 17) and T O (Fig. 18) should each of them be made equal to half the circumference of a circle having A O (Fig. 10) for its diameter, and then divided into as many equal parts as semi circle A *d* O (Fig. 16) is divided into. In practice, for convenience in making up, it is necessary to cut off the point O (Fig. 17) of the pattern. How much shall be cut off must be left to the experience of the workman; it varies according to the size of the "boss" used to cover the throat. Also, in practice, to ensure neatness of fitting, the rim at O (Fig. 16) is notched out a little. This, again, is a matter in which experience must be the workman's guide.

The rim being cylindrical, its pattern needs no description beyond saying that it is a rectangle, one side of which is equal to the depth of the rim, and the other sides equal to the circumference of a circle having A O for its diameter.

NOTE.—In practice the usual sizes of rim A O Q P and hood T S R O are as follows:

Diameter of Cowl.	Depth of Rim.	Size of Hood at Widest and Narrowest Parts.
8 inches.....	2 inches.....	4 inches and 1 inch.
9 "	2¼ "	4½ " 1⅛ "
10 "	2½ "	4¾ " 1¼ "
11 "	2¾ "	5 " 1½ "
12 "	3 "	5½ " 1¾ "

PROBLEM VIII.

Pattern for a tapering circular bend.

The method here given is approximate, as indeed all ordinary practical methods must be for problems of this description.

Let K' K B' B H H' *q'* Q' (Fig. 19) represent in elevation the side of the ship's ventilator or fog horn.

Divide each of the curves B B′ K K′ and H H′ Q Q′ into as many equal parts as it is determined there shall be segments, here say three parts, the points of division being B′, K, and H′ Q, respectively. Joining B′ to H′, and K to Q we have in B B′ H′ H, B′ K Q H′, and K K′ Q′ Q elevations of the three segments of

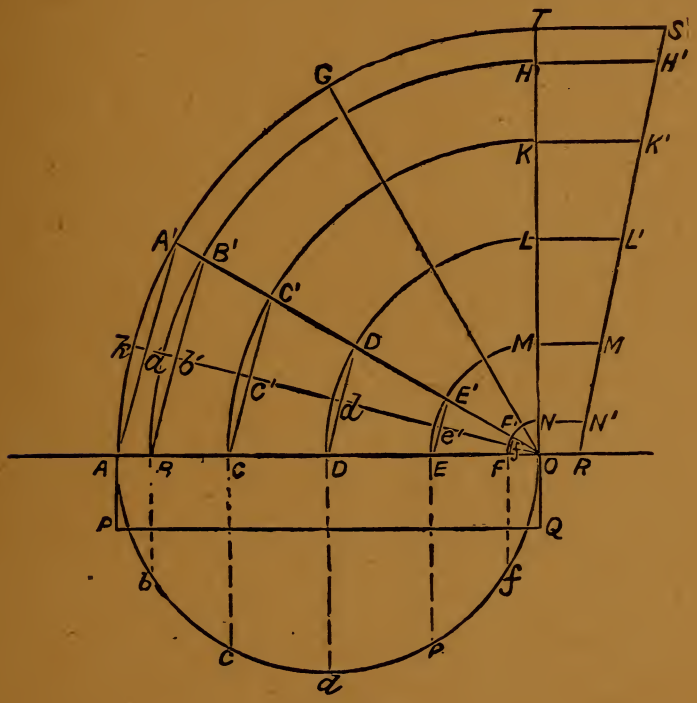


Fig. 19.

which the ventilator is to be made up; T R H B is an elevation of the mouthpiece of the ventilator.

To draw the pattern for the segment B B′ H′ H.

Bisect the arc B′ B in a' and H′ H in h', and join $a'h'$; also join B′ B. On $a'h'$ describe a semi-circle a' $e'h'$ and divide it into any number of equal parts—here

six—in the points $c' d' e' f'$ and g'. From these points draw lines perpendicular to $a' h'$, cutting $a' h'$ in the points c, d, e, f and g respectively (to avoid confusion these lines are not shown in the figure), and through c, d, e, f and g draw C′ C, D′ D, E′ E, F′ F, and G′ G parallel respectively to B′ B.

Next draw (Fig. 20) an indefinite line $b\ h'$, and set off on it distances $b\ c$, $c\ d$, $d\ e$, $e\ f$, $f\ g$, and $g\ h'$, each equal to $a' c'$ (Fig. 19), that is to one of the divisions of the semi circle $a'\ c'\ h'$, and through b draw B′ B at the same angle to $b\ h'$ that B′ B (Fig, 19) is to $b\ h'$. Now through c, d, e, f, g and h' (Fig. 20) draw C′ C, D′ D, E′ E, F′ F, G′ G and H′ H, parallel respectively to B′ B. Make b B, c C, d D, e E, f F, g G, and h' H equal respectively to b B, c C, d D, e E, f F, g G, and h' H (Fig. 19). Also b B′, c C′, d D′, e E′, f F′, g G′, and h' H′ equal respectively to b B′, c C′, d D′, e E′, f F′, g G′, and h' H′ (Fig. 19). Joining B, C, D, E, F, G, and H, and B′, C′, D′, E′, F′, G′, and H′ by unbroken curved lines gives in B H H′ B′ the pattern required.

To draw the pattern for the segment K′ K Q Q′.

Bisect the arc K′ K in j and Q′ Q in q', and join $j\ q'$; also join K′ K. On $j'\ q'$ describe a semi-circle $j\ n'\ q'$ and divide it into any number of equal parts—here six—in the points l', m', n', o', and p'. From these points draw lines perpendicular to $j\ q'$, cutting $j\ q'$ in the points l, m, n, o, and p respectively (these lines are not shown in the figure), and through l, m, n, o, and p draw L′ L, M′ M, N′ N, O′ O, and P′ P, parallel respectively to K′ K.

Next draw (Fig 21) an indefinite line $k\ q'$ and set off on it distances $k\ l$, $l\ m$, $m\ n$, $n\ o$, $o\ p$, and $p\ q'$ each equal to $j'\ l'$ (Fig. 19), that is, to one of the divisions

of the semi-circle $j\ n'\ q'$, and through k draw K′ K at the same angle to $k\ q'$ that K′ K (Fig. 19) is to $k\ q'$. Now through l, m, n, o, p, and q' (Fig. 21) draw L L′, M M′, N N′, O O′, P P′, and Q Q′ parallel respectively to K K′. Make k K, l L, m M, n N, o O, p P, and q Q, equal respectively to k K, l L, m M, n N, o O,

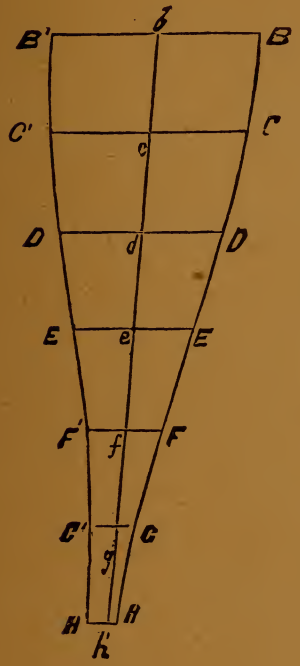


Fig. 20.

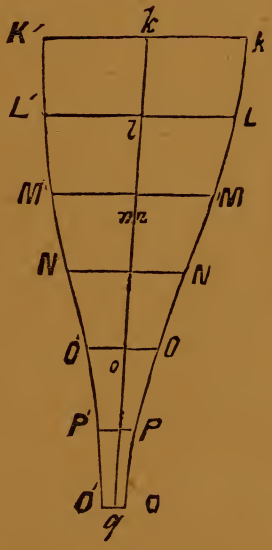


Fig. 21.

p P, q' Q (Fig. 19). Also make k K′, l L′, m M′, n N′, o O′, p P′, and q' Q′ equal respectively to k K′, l L′, m M′, n N′, o O′, p P′, and q' Q′ (Fig. 19). Joining K, L, M, N, O, P, and Q, and K′, L′, M′, N′, O′, P′, and Q′ by unbroken curved lines gives in K Q Q′ K′ the pattern required.

In practice it is found desirable to leave the ends H′ H (Fig. 20) and Q′ Q (Fig. 21) of the patterns full long. It is easier to cut a piece off if a pattern is too long than to add a piece if too short.

The pattern for the segment K B′ H′ Q need not be drawn here. To do so would make a confusion of lines in the figure. It can be obtained in similar manner exactly to that by which the patterns are obtained of the other two segments.

The mouthpiece of the ventilator can be stretched out of a disc, or can be made from a part cone and stretched.

CHAPTER IX.

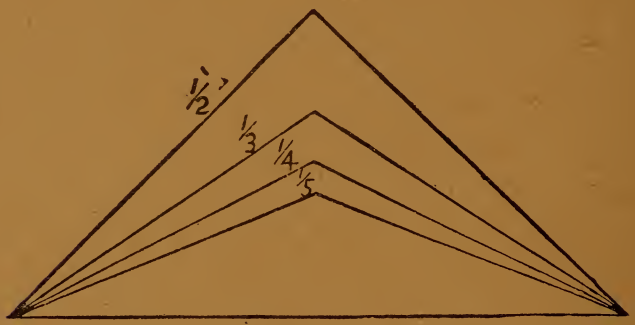
SLATE.

Strength of Building for Slate.

It is the prevailing opinion of people not familiar with the use of slate for roofing purposes, that a building should be constructed very much stronger for slate than for other roofing materials. This is a great mistake, as *any building strong enough for shingles, tin or iron is strong enough for slate*, for the following reasons: The weak points of any roof are the valleys or other breaks in the roof where snow drifts in and lodges, and when the snow melts with rain the weight at points where the snow has drifted is much heavier than any two slate roofs. It is well known that snow will not stick on a slate roof as it will on shingles or on a metal roof. as the slate being of a warmer nature causes the snow to melt and slide off; while with shingles or metal it freezes on, causing greater weight than a slate roof is ever called on to bear. Two by six rafters, eighteen feet long, two feet from centers, gives a roof all the strength necessary for a slate roof. The writer has seen hundreds of houses roofed with slate where the rafters were two by four, two feet from centers, sixteen feet long, with collar beam nailed across one-third of the way down from the top.

Pitch of Roofs.

Slate can be depended upon to make a roof perfectly water tight on any pitch down to one-fifth. Half pitch or steeper makes the best roof both for looks and



The above shows the different pitch of roofs on which slate is usually laid. Slate should not be laid on a roof of less than one-fifth pitch.

strength, as it throws the weight on the walls more than the rafters, and causes the snow to slide off clean, thereby never overloading any one part of the roof.

Sheathing Boards.

Matched lumber is best for sheathing for any roof, surfaced boards from six inches to ten inches wide make a good job and are used on a large majority of the buildings now being put up. Sheathing boards, when not matched, should be nailed at both edges on rafters, which should not be over two feet apart. Wide boards when used for sheathing are liable to warp and curl up at the edge, thus affecting the slate. While it may not break the slate it raises the courses, marring the appearance of the roof. Very often a roof that lays well and smooth when done apparently gets rough and the slates stick up. The roofer is often blamed for this when the

cause is really in the sheathing. Great care should be used in putting on sheathing that there are no lumps or uneven thicknesses in the boards, as they will surely show after the slate is put on. This especially applies on curved roofs or round towers, dormers, etc. In all such, the rafters should be close together and the sheathing perfectly solid and smooth. Where the sheathing is not solid it is almost impossible to make a good smooth job, for the reason that in driving one nail it jars the next slate loose. Laths or strips are often used instead of sheathing boards on which to lay slate, but in such case the lath should be at least one and one-quarter by two and one-half inches, and must be spaced to suit the size of the slate used. They should be placed so that the upper end of each slate will rest in the center of the lath. This plan is a good one for barn roofs, as it allows some ventilation between the slate; but where a perfectly snow-tight roof is wanted, the slate should be pointed with hair mortar on the underside of the slate at the upper end of each course, also the joints between the slate. Tarred or other water-proofed paper should be used under slate where the same is laid on sheathing boards. This will insure a roof perfectly tight against fine snow.

Comparative Size and Strength of Slate.

A wide and short slate makes the strongest and best roof, and looks much better than the long narrow slate after one is accustomed to the appearance of roofs finished in this style. Slate 10 × 14 is 40 per cent. stronger than that 7 × 14; 12 × 16 is 50 per cent. stronger than 8 × 16; 10 × 16 is 25 per cent. stronger than 8 × 16; 12 × 18 is 33 per cent. stronger than

9 × 18, and the same applies to other sizes both larger and smaller. The above sizes refer more particularly to dwellings, and the figures are based on facts which you can easily demonstrate by actual test. By the use of the above sizes the actual strength and wear of a roof can be increased from 25 to 33 per cent., while the cost is no more. The above should be thoroughly impressed upon all who intend using slate or going into the business. For barns, shops and other large buildings 14 × 24, 14 × 22 and 14 × 20 make the best; 12 × 24, 11 × 22 and 12 × 22 make a fine roof. As is well known, the best material in the quarry is split and worked into the larger sized slate; the latter also takes less nails and can be put on much faster than the smaller sizes. About four-fifths of all the slate specified by architects are either 8 × 16, 9 × 18 or 10 × 20; while not much more than one-tenth of all the slate made is cut to these sizes. This being the case, it is evident that a great many must use slate of a size different from that called for in the specifications.

There is always a scarcity of medium sizes. The smaller the slate the more nails and time required to lay them on the roof, and the more small pieces are needed on hips and valleys. In quarrying and making the slate the rock is blasted out in large blocks, then broken and split up into blocks to as near the size of the slate as possible, then split with thin chisels and mallet to the thickness of the slate, then dressed square on a machine, each splitter and dresser making about thirty different sizes of slate, the size being regulated by the size of the blocks and sheets of slate split from the same—the dresser always trimming the piece to the largest size it will make. There is a great waste

and extra expense in making any special size of slate in a larger quantity than the usual average.

How Slate Roofs Are Damaged By Carelessness.

After a roof is finished the slater should insist that tinners, painters, carpenters and others keep off the slate or lay boards or ladders to walk on, and if they will trample them and break the slate, they should pay for the repairing. It is a notorious fact that tinners, carpenters, painters, masons, and, worst of all, lightning-rod men, damage slate roofs more before the building is finished than will ten years' wear. This can only be stopped by the slaters insisting on their rights and not allowing themselves to be robbed by coming back and repairing a roof three or four times after the slate has been trampled up and broken by careless workmen.

Ornamental Slate.

Slate of one color with cut belts is very much used. The old style of red, green, black and purple spots and stripes is fast going out of date, as it should. A gaudy striped and spotted roof may attract the eye when new, but a plain, neat roof of all one color, or not more than two colors, always looks well. Black and green make the best contrast where more than one color is used. They should be run in belts, either through the center of roof or a belt at top and bottom. The less gaudy figures put in the better the roof will look. It is much less difficult to get at the amount of slate necessary to ornament a roof if belts are used instead of figures.

The custom which prevailed several years ago,

of using gaudy ornaments of different colored slate, has entirely changed and it is now very seldom that even two colors of slate are put on the same roof, but the custom of cutting the slate has increased with the decrease of colors. Many fine buildings now are roofed with all cut slate. Whole roofs of small red, or black slate, all cut, are very effective, and much used and admired by the best judges of such work.

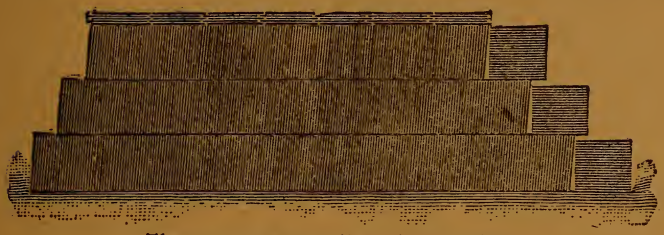
Cut Slate Make The Neatest Roof.

It is much easier to make a smooth roof with cut slate, or with alternate belts of cut and plain slate, than with all plain. The reason of this is that the eye always detects a slight defect or unevenness on a plain surface much quicker than on broken surfaces. It is better to use from ⅓ to ½ of the slate cut to pattern for the best class of work. This adds little or nothing to the cost of the roof, as with the improved machines, now used by all leading roofers, the slate can be cut to almost any conceivable pattern. A great variety not shown here can be made according to the taste and skill of the workmen, and there is room for the display of a great amount of taste and judgment in laying out the cut slate for a roof, cut up by hips, valleys, gables, dormers, etc. The appearance of the whole building is often greatly improved by a neat, tasty arrangement of the cut slate in the roof.

Piling Slate.

It may appear, to a casual observer, of very little consequence how roofing slate are piled, either at the quarry or when hauled to the building ready for use.

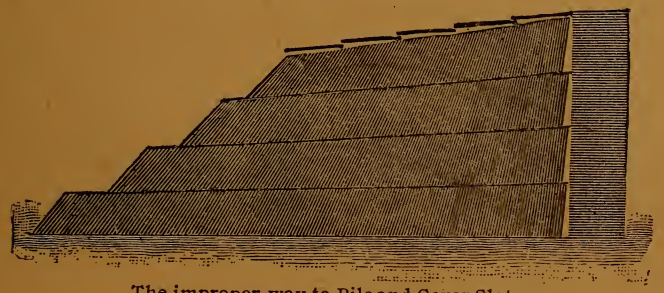
It is not necessary to tell quarrymen how to pile slate except to caution them not to pile so high as is usually done, especially where room on the banks is scarce. The piles should in no case be more than three feet six inches high; if piled more than this height and allowed



The proper way to Pile and Cover Slate.

to stand over winter there will be a heavy loss in breakage in the bottom rows of the piles.

These remarks are intended more for beginners than for old hands, whether quarrymen or slaters, and should be carefully studied and followed. It is necessary to have a solid dry place to pile slate; then a plank or



The improper way to Pile and Cover Slate.

strips should be laid down (the first named being preferable), and there should be lath or strips between the piles. Where there is no wall to pile against there should be bulkheads built, as shown in the following cut:

The above method of covering is intended for use in

the fall when much rain or snow is expected, to prevent the slate from freezing together, which makes it very disagreeable work handling, besides causing much waste.

I am sorry to say this plan is the one more often followed than the first. This plan is very expensive in broken slate, the piles very often falling down or getting out of shape. The slate in a pile exert a great pressure in the direction of the slant at the top, and the more they settle the heavier the pressure.

Selecting Slate.

Much time can be saved in laying slate by carefully selecting when punching. Where there are corners off, thin corners or other imperfections, the slate should be punctured so the imperfect part will be the head of the slate when laid, unless the imperfection is of such a nature that it will damage the roof; in which case the imperfect slate should be laid out to use on hips or valleys. The slate should be selected in two thicknesses; the thick slate to be laid at the eaves and the thin ones at top of the roof. Finishers, however, should be thick and all perfect slate. It is a great advantage in dressing to use a machine, as it makes a very much stronger job and neater hole.

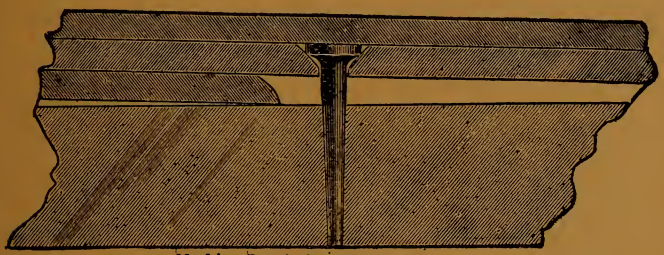
Punching Slate.

Slate punched by hand is more liable to come loose than machine punched, for the reason that in punching by hand the slate is only supported on one side of the hole at the time the point of the hammer strikes the slate; and in consequence a large piece usually scales off, often leaving not more than one-half of the thick-

ness of the slate to hold the nail. The result is the slate is so weak the nail head pulls through and the slate comes off. See the following cuts showing both hand and machine punched slate.

Machine Punched Slate.

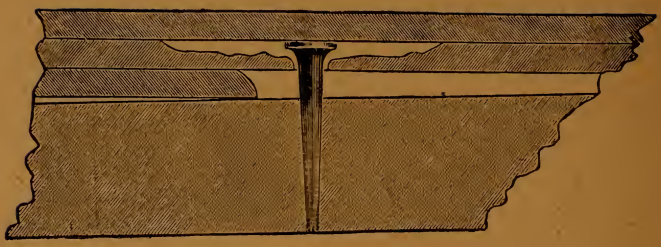
The following cut shows a section through the slate at nail hole when punched with machine. It can readily be seen that this form of nail hole gives the greatest possible strength to the slate and the least possible chance for the nail pulling through, while the slate



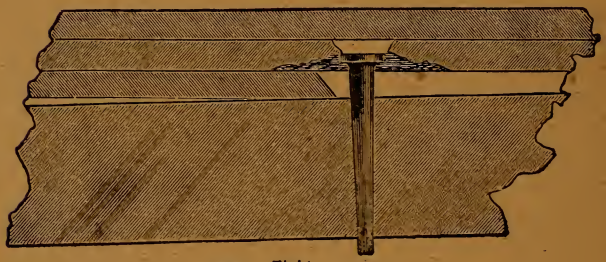
Machine Punched Slate.

punched by hand are greatly weakened, as nearly every slate is scaled off around the hole, reducing the slate nearly, if not one-half its thickness. This is the principal cause of so much repairing being required on roofs put on before the introduction of machines for punching.

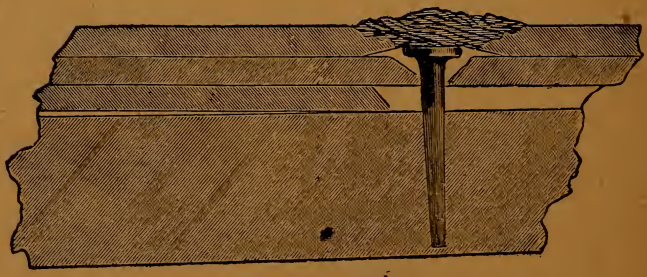
The following cut shows a section through the nail hole in hand punched slate. A comparison of the above cuts will quickly convince any man with reasonable judgment which method is preferable, and that as a matter of economy and durability the first is far in advance of the latter.



Hand Punched Slate.



Nails Driven too Tight.



Nails not Driven Far Enough.

Nailing.

Nails driven too tight produce the effect shown in the above cut and should be carefully avoided by slaters; this applies more particularly to slate punched by hand, as the slate does not have much strength to hold the nail and consequently pulls through and allows the slate to slide out.

Nails not driven far enough are nearly as bad and produce the effect seen in the above cut; while it does not allow the slate to slide off, it punches holes through the slate above the nail; this is caused by the weight of the bracket or by walking on the roof; nails should be driven down until the head is level with top surface of the slate but not tight enough to draw or spring the slate.

Slating Nails.

During the last few years there has been a change in this line from cut nails to wire nails. The principal reason for this has been the poor quality of the cut nails, nearly all makers producing clumsy, heavy nails with thick, ragged heads, while the wire nail is generally clean cut, well made, with countersunk head. A clean, well made, cut steel nail with countersunk head is better than wire nails for the purpose of laying slate, for the reason that it is almost impossible to cut or break a wire nail in repairing, while a cut nail readily breaks or cuts with the ripper, making it much easier to repair. Another advantage in cut nails is that it requires more force to start a cut nail than a wire, although the wire nails hold more after starting to pull than the cut. Both make a good job. Galvanized or tinned nails are less liable to rust. Either cut steel or steel wire nails rust much less than iron nails. Copper

nails are often used on fine work, but they cost much more and pull out of the sheathing very much easier than steel. 3 d nails are large enough for all sizes of slate up to and including 20 inches; unless the slate are extra thick above 20 inches 4 d should be used.

Measuring Roofs.

It is very essential that a slater should be able to understand and measure architects' drawings, as many of the largest and best jobs of slate roofing are let by contract from the architect's office. The greatest advantage derived by the slater, in being able to measure drawings, is the fact that his competitor does not know every job he bids on; just how much per square he figures at, as the variation in prices may be caused by measure and not price. Where the competition bidding is all by the square, the result is generally to run the price down gradually but surely until there is no profit, and often an actual loss in many of the jobs done. Some roofers adopt the mistaken plan of not measuring hips and valleys extra; this is wrong, for while it may give a small margin of profits on a plain roof, at the same price per square it will cause considerable actual loss on a roof badly cut up by hips and valleys. There is no more reason or sense in leaving off the measure of hips and valleys than there would be to leave it off the measure of the porches, as both take a great amount of extra time and material which the owner gets the benefit of, and should pay for, as he does for windows, doors, or any other part of his house.

Rules For Measuring Slate Roofs.

The following are the standard rules for measuring slate work. These rules are recognized and followed

by roofers, architects and engineers wherever slate roofing is used, and in all standard works on the subject:

For Plain Roof.—Measure the length of the roof and multiply by the length of the rafter.

For Roof with Hips, Valleys, Gables, Dormers, Etc.—Measure each section through the center and multiply by the length of rafter; and in addition to the actual surface of roof measure the length of all hips and valleys by one foot wide, also what the first, or eave course, shows to the weather by the length of eaves. *In some localities this rule is not adhered to strictly, but hips and valleys are always measured wherever slate is used.* The extra measure on eave course is to compensate for lost time in standing and laying the under-eave course, which does not show or count in the surface measure. The extra measure on hips and valleys is intended to compensate for extra labor and loss of material in cutting, fitting and laying same. No deduction is made for dormer windows, skylights, chimneys, etc., unless they measure more than four feet square. If more than four feet square and less than eight feet square, one-half is to be deducted. If more than eight feet square, deduct the whole. The reason for not deducting the whole of the openings is the extra work in cutting and fitting the slate, and putting in the flashings. Hips and valleys on spires are measured extra, same as above. If hips are mitred and flashed they should be charged for extra. If ridge-roll is put on it is charged extra. Gutters, valleys and all flashings are charged extra.

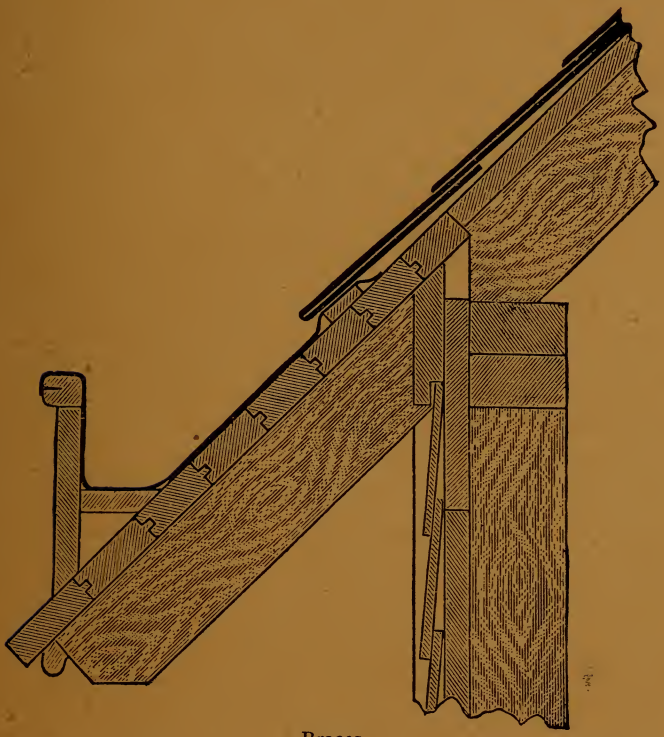
It should always be remembered, in measuring roofs, that if the pitch of the roof is the same, size of building and projections the same, the mere fact that there are hips and valleys does not add to the surface of roof.

As an example: Two buildings of the same size may be roofed—one with plain pitch and gable roof (this is, two plain sides), and the other may have four hips, four gables and eight valleys. If both roofs are the same pitch, the roofs will measure exactly the same, and two measures is all that is necessary in measuring either—that is, the length of one eave and the length over both rafters, except that the extra measure on hips and valleys would have to be added on the cut up roof.

Laying Slate and Felt.

Before starting, the slater should be sure the roof is ready. The carpenter should put on a cant strip about one-quarter inch thick, nailed about two inches above the eave line of the slate. Carpenters often refuse to do this, saying it is the slater's work. This is not true. It is as much a part of the carpenter work as the sheathing. There should be cant boards put in behind all chimneys before the chimney back or gutter is put in. The cant board should fall to each end so that no water will stand in the gutter, as is the case where no cant board is used. This is the cause of more bad leaks on slate roofs than any other one thing; it is worse than broken slate, as the water will, where the end of a chimney gutter is higher than in the center, run over and follow along the under side of the tin to the lowest point, then drop off and run down, often allowing gallons of water to run into the building in a few hours. It is a good plan to keep small sea green slate on hand for under-eaves, as they are cheap and strong, making the very best for the purpose. When chimneys require braces they should be put on where practicable, so that the end that is fastened to the roof will be higher than

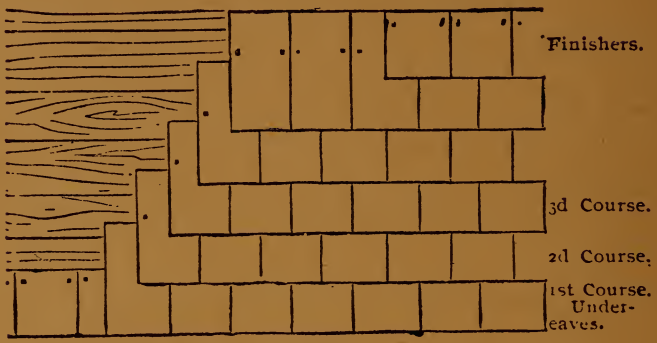
the end fastened to the chimney; this will prevent water from following the iron rod down through the slate, but where the braces must be lower at the end next to the roof, then the brace should be built so that there will be a drip formed near the roof.



Braces.

The slaters should be very particular to put boards in the gutters, so that the metal cannot be injured by tramping or by pieces of slate. In nailing slate on, great care should be used that the nails should not be driven down too tight, as they will pull through, and on the other hand they should be driven down even

with the slate, so that the nail will not punch the slate above when pressure is put on from above by stepping on the slate, or by the scaffolding.



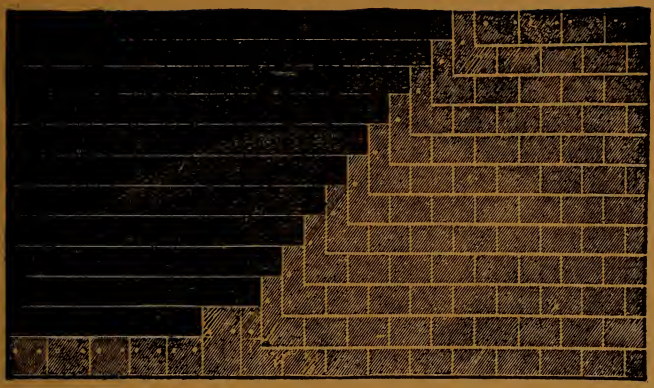
Starting and Finishing.

The above shows how to start and finish a roof.

The lap is the amount the tail of the third course laps over the head of the first course.

Flashing and Counter-Flashing.

Flashing and counter-flashing should always be separate. The single-flashing should be laid in with the courses of slate, one piece under the lower end of the first slate or half slate intersecting any wall or chimney, and should be two inches longer than the gauge of the slate (the slate are laid to weather), and six or seven inches wide. Turn up square two and one-half to three inches. The part turned up against a chimney or wall should never be nailed to same, for the reason that the wood work of the roof will settle more than brick or stone work in chimneys or walls and cause the flashings, if nailed, to tear up the slate. The counter-flashings should be let into the brick or



Head Lines on Felt.

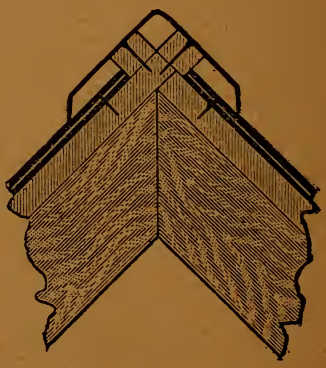
Flashing and Counterflashing.

stone joints one inch, well wedged in and pointed with mortar. The pointing is a part of the masons' work. If grooves have to be cut in the stone or brick work to receive counter-flashing, it is the masons' work to cut them. Counter-flashing is usually done by the tinner. If lead is used for flashing, no heavier than two and one-half pounds to the square foot should be used for the part interlapping with slate. If thicker is used it makes the slate lay badly. Flashing should never be put in in long strips, but always cut and laid in with the courses. A great source of trouble and leaks is the manner in which chimney backs are usually put in.

Ridge and Hip Rolls.

Galvanized iron ridge and hip rolls make a much better job than slate finish, as they hold the finishers and pieces to hips so that wind cannot catch them.

Ridge Roll.



Ridge Saddle.

Whenever possible, a wood strip should be nailed on each side of hips and along comb, to nail ridging to. The ridging should be so shaped that it will press down tight on the slate when nailed on.

Neither hips nor ridge should ever be finished without ridging, as it is inexpensive and adds so much to appearance and durability of the work. Ridge and hip rolls are always figured separate from the slate and charged for at so much per foot. The reason for this is that often a large job has very little hips or ridges, while often a few squares, such as spires, may have hundreds of feet of ridge or hip roll.

Ridging.

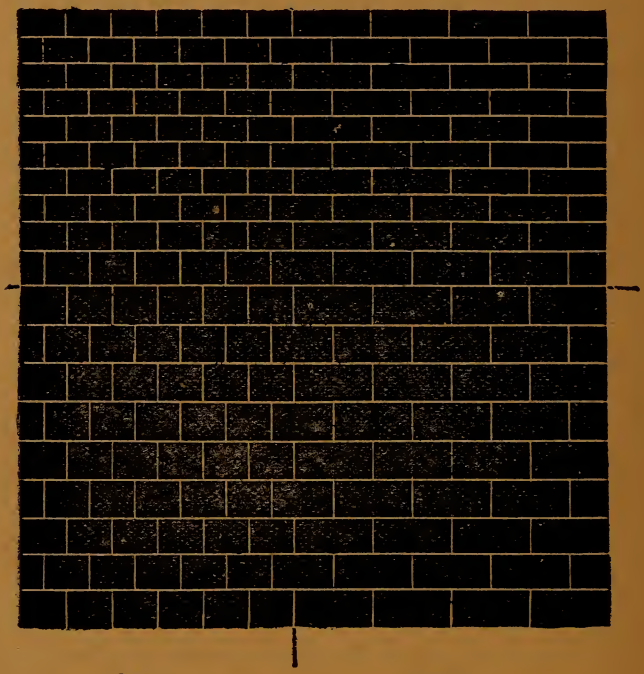
Ridge and hip rolls used on plain work should be put on by the slater, so that when the slate are broken they can be replaced, leaving the roof complete; another reason why the slater should put the ridging on is, that a slater knows where to drive a nail so as not to break the slate better than other mechanics who are not accustomed to doing such work. Two inch steel wire nails are the best for fastening ridgings. Great care is necessary in nailing on ridging not to drive the nails too tight, thereby cracking the slate or making kinks in the flange of the ridging.

Ridging, flashing, etc., is not considered a part of a slate roof and is charged extra per foot, according to the amount of the same.

How to Use Several Sizes of Slate on One Roof.

On account of the long distance that slate has to be shipped and the length of time it takes to get a car load through, it often happens that the slater may have slate enough for a job but not enough of one size, or even for one side of the roof. We have prepared the accompanying cut to show the manner of using different

sizes of slate on the same section of roof. The cut shows four sizes, but more can be worked the same way; for example: take a roof twenty feet long and twenty feet rafter—there are four squares—now suppose you have one square 10 × 16, one square 8 × 16, one square 10 × 14, one square 8 × 14. Start with



Sizes of Slate.

10 × 16, when half way across the eave run 8 × 16 the other half, then run up ten feet on the roof with these two sizes, the two sizes joining in the center; then start on the 10 × 16 with 10 × 14, and over the 8 × 16 lay 8 × 14. If more than four sizes are to be used divide the roof into sections according to the slate to be used.

Round Tower.

In some classes of work it is necessary to also cut the upper end of the slate. This is called shoulder cutting, and makes the slate lay down much better than will slate with full corners. This especially applies to slating round towers, which is now coming into much favor. It is really impossible to make nice close job on round towers or dormers without shoulder cutting. In slating a round tower or dormer it is best to start with wide slate, 10 × 12, 10 × 14 or 10 × 16 are good for starting them. As each course narrows down you get up much higher. Before the slate gets too narrow to cover the nails below, after running up until the slate gets down to 3½ to 4 inches, it is best to start again with a course double the width of the last course, and thus have the width to narrow down on again, as two inches is about as narrow as it is safe to make the last course, and even then it is well to carefully double felt and lay several of the last courses in oil cement.

Repairing of Slate Roofs.

Many slaters think they have a perfect right to charge a ruinous price for repairing because they do it by the day. This class of so-called slaters never succeed in building up a permanent business and are almost certain to finally bring up in the hands of the sheriff, no matter how prosperous they may appear at first. They do more damage to the slate business than any other one thing known. They do a poor job of roofing and depend on making money by repairing. In putting on a new roof every slate should be left whole and perfect, both nails should have their full hold, and

the slater should feel that each slate is right before covering it up with the next. The same care should be used in repairing. Take out every slate that can possibly cause a leak, and carefully replace it. If the roof is steep and the slate twenty inch or larger, put in two nails—the upper one as close up in center joint as possible, the other two inches lower down. Over the head of the nails slip a piece of painted tin, about 3 × 6 inches; bend the tin so it will bind and not slip

Repairing a Slate Roof.

out. Putty or cement is sometimes used for the nail heads, but neither is good. Leaks are often caused by cracks in the slate above the gauge line, so that it is only by close scrutiny the leak is found. Leaks are also caused by a rough surface on the slate near the head, causing the water to run across the slate. This is very often the case with hand punched slate, as large pieces are frequently scaled off, which catch the water, running it in around the nail.

The dotted lines show the piece of tin over the nail; the light shaded space shows where the broken slate is taken out and replaced.

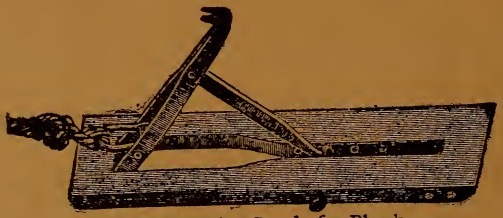
Tin slipped over nail head.

This shows the shape of the piece of tin before being slipped in over nail head. Putty or cement should never be used in repairing to cover nail head, as they will not last.

Slaters' Scaffold Bracket.

The above cut shows the method now generally adopted by slaters for scaffolding a roof. The scaffold can be made in two ways, the old way being to nail up a bracket at the building from pieces of board. This is a slow, expensive plan and often very dangerous. The safer and better plan is to have adjustable brackets

that can be changed to any pitch or roof instantly and folded up when not in use. The above cuts shows a very convenient bracket and the plan of using the same on the roof. A light and convenient extension ladder is the most convenient way to get slate upon small buildings; for buildings more than two stories it is bet-



Scaffold Bracket Ready for Plank.

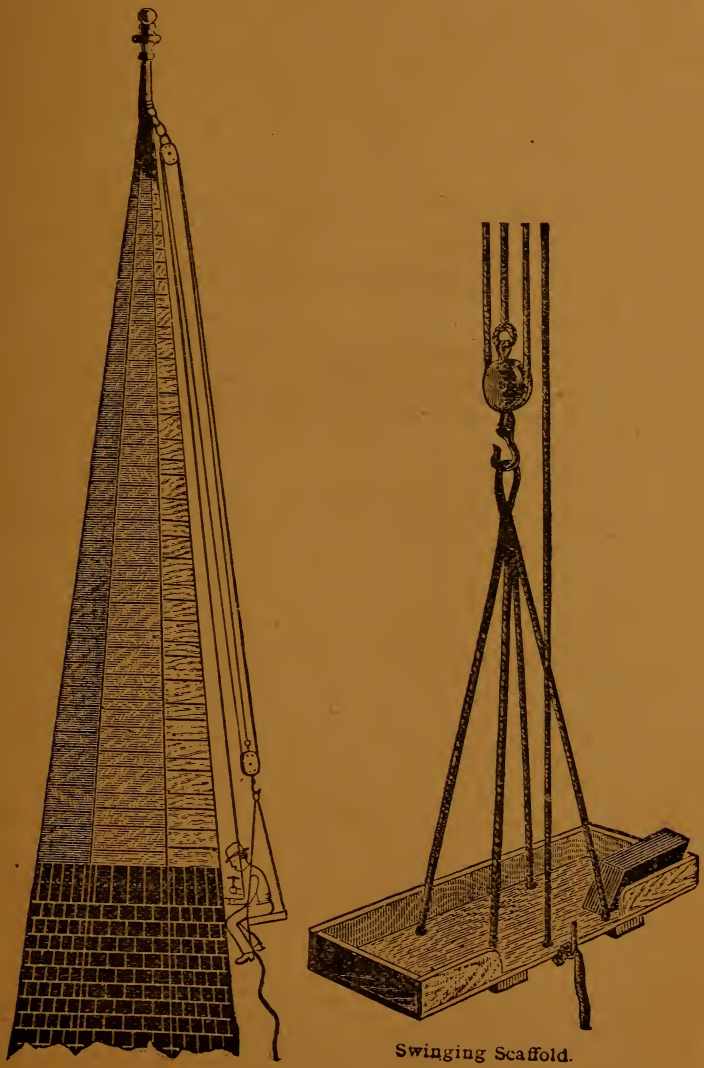
Bracket Closed when not in Use.

ter to use a rope pulley and pull the slate up to the gutter, using a ladder to carry the slate from the gutter up to the scaffold where slaters are at work.

Spire Slating

Is done in two different ways. The first and usual way being to use the carpenters' scaffold for putting on the slate, leaving out slate where the scaffold timbers come through until done; then take the scaffold down from the top, finishing the ridge and repairing as you come down. The other and more difficult plan is to put the slate on from a chair or swinging scaffold, as shown in the engraving. This is the plan used when there is no carpenters' scaffold. When this plan is used it is customars to build a small scaffold around the spire at the highest point that can be

reached from the inside through an opening. It is very handy to have a scaffold around the base of spire from which to start.



Swinging Scaffold.

The German Style,

In which the slate are laid horizontal instead of vertical, is often used on convex roofs, towers, etc., and makes a very fine appearing roof, as the slate lay down

German Style.

much closer on curved roofs than if laid in the ordinary way. For this plan a short, wide slate works and looks best; 8 × 10, 10 × 12, 10 × 14 and similar sizes being preferable. The slate should lap about three

inches on the end and about 2 inches on the side, which would be at the top. One hole is punched at the top and one in the end, as shown in engraving The slate can be laid square or one corner can be cut as shown. Nothing but the best and strongest slate should be laid in this way, as a broken slate leaves the roof exposed. This plan is not suitable for large slate and when the same are used they make a very poor roof.

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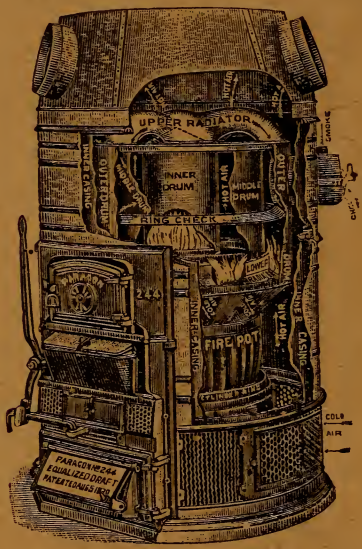

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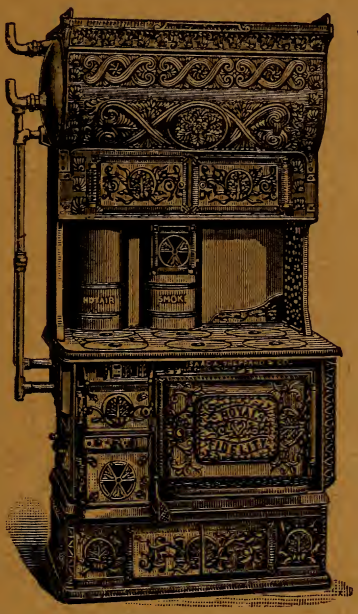

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Two-quart Coffee Pot
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Four-quart Coffee Pot
Five-quart Coffee Pot
No. 1 Coffee Boiler
No. 2 Coffee Boiler
No. 3 Coffee Boiler
Lamp Filler
One-pint Dipper
One-quart Dipper
Two-quart Dipper
Four-quart Flaring Pail
Six-quart Flaring Pail
Eight-quart Flaring Pail
Ten-quart Flaring Pail
Twelve-quart Flaring Pail
Fourteen-quart Flaring Pail
Ten-quart Dish Pan
Twelve quart Dish Pan
Fourteen-quart Dish Pan
Sixteen-quart Dish Pan
Dinner Bucket
Five-inch T-Joint
Six-inch T-Joint
Eave Trough Mitre Joint
"Snap" 2-inch Conductor Elbow
Cullender
Two-inch Square Elbow
Two-and-a-half-inch Square Elbow
Three-and-a-half-inch Square Elbow
Four-and-a-half-inch Square Elbow
Five-and-a-half-inch Square Elbow
Six-and-a-half-inch Square Elbow
Seven-and-a-half-inch Square Elbow
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Two-pint Funnel
Three-pint Funnel
Four-pint Funnel
Large Milk Strainer
Small Milk Strainer
Ten-quart Milk Pail Breast
Fourteen-quart Milk Pail Breast
Two-inch Four-Piece Round Elbow
Three-inch Four-Piece Round Elbow
Four-inch Four-Piece Round Elbow
Five-inch Four-Piece Round Elbow
Five-and-a-half-inch Round Elbow
Six-and-a-half-inch Round Elbow
Seven-and-a-half-inch Round Elbow
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Medium Grocers' Scoop
Large Grocers' Scoop
Apple Corer
Oval Foot Bath
Oval Pudding Pan
Half-gallon Can Breast
One-gallon Can Breast
Two-gallon Can Breast
Three-gallon Can Breast
Half-pint Measure
One-pint Measure
One-quart Measure
Half-gallon Measure
One-pint Basin
Two-pint Basin
Three-pint Basin
Four-pint Pan
Six-quart Pan
Ten-quart Pan
Small Cake Pan
Medium Cake Pan
Large Cake Pan
Small Wash Basin
Large Wash Basin
Sprinkler Breast
Four-gallon Churn
Five-gallon Churn
Small Dust Pan
Large Dust Pan
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